ARMED FORCES CHEMICAL JOURNAL

1907 GOLDEN ANNIVERSARY, 1957

—U.S. Air Force

UNITED STATES AIR FORCE

MAY-JUNE 1957


When the first message from the moon flashes back to Earth
At that moment, research will gain another victory over the unknown.
How many millions will be listening? Surely the scientists and engineers who have spent dozens of years and countless dollars to develop featherweight fuels, electronic navigating devices, limitless sources of energy.
Perhaps members of this year's high school graduating classes will be listening, too. Some of them may help build and equip the first space ship. One of them might pilot it—and send that message to the anxious Earth.
Other realms of research—just as satisfying, just as spectacular—also need today's young men and women. The discoverers of penicillin, plastics, synthetic fibers, DDT and aerosols weren't aiming for the moon, but they found, under their microscopes and in their test tubes, universes in miniature.
America's fast-growing chemical industry spends more in research than any other industry—$400 million this year. Every cent is worth it if DIAMOND ALKALI COMPANY and other chemical companies can continue to transform the raw materials of our forests, mines, seas—even the air—into new products that will serve all of us better.
Diamond Chemicals
Contribute every day to everyone's progress everywhere

ARMED FORCES CHEMICAL JOURNAL

OFFICIAL PUBLICATION OF THE ARMED FORCES CHEMICAL ASSOCIATION

SUITES 408-410, 2025 EYE STREET, N.W., WASHINGTON 6, D.C.

VOLUME XI | MAY-JUNE 1957 | NO. 3

POLICY

The fact that an article appears in this magazine does not indicate approval of the views expressed in it by any one other than the author. It is our policy to print articles on subjects of interest in order to stimulate thought and promote discussion; this regardless of the fact that some or all of the opinions advanced may be at variance with those held by the Armed Forces Chemical Association, National Officers, and the Editors. It is the responsibility of contributors, including advertisers, to obtain security clearance, as appropriate, of matter submitted for publication. Such clearance does not necessarily indicate indorsement of the material for factual accuracy or opinion by the clearing agency.

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COVER PHOTO

Flying skill and precision are depicted in this U.S. Air Force color photo of an oil painting showing the Air Force "Thunderbirds" in action at Nellis Air Force Base, Nevada. The "Thunderbirds" are a special demonstration team flying North American F-100 "Super Sabre" jet fighters. They tour Air Force Bases and give public demonstration of their special skills.

The "Thunderbirds" will give a precision flying demonstration at Andrews Air Force Base during the classified program for A.F.C.A. there on May 24.

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Published bi-monthly—Jan.-Feb.; Mar.-Apr.; May-June; July-Aug.; Sept.-Oct.; Nov.-Dec.—by the Armed Forces Chemical Association, National Headquarters, located at Suite 819, 2025 Eye St., N.W., Washington 6, D.C. Entered as second class matter at the Post Office at Washington, D.C., under the Act of March 3, 1879. Additional entry at Nashville, Tenn. Subscription price $3.00 per year to members; $6.00 per year to non-members in the United States, Canada and Mexico; elsewhere $1.00 additional for postage. Inquiries concerning circulation and advertising should be addressed to the Secretary-Treasurer.

ARMED FORCES CHEMICAL ASSOCIATION

National Headquarters

408-410 Park Lane Building—2025 Eye Street, N.W.

WASHINGTON 6, D.C.

(Republic 7-6803)

The members of this Association, mindful of the vital importance to national defense of chemistry, allied sciences, and the arts derived from them, have joined together as a patriotic obligation to preserve the knowledge of, and interest in, national defense problems derived from wartime experience; to extend the knowledge of, and interest in, these problems; and to promote cooperative endeavor among its members, the Armed Services, and civilian organizations in applying science to the problems confronting the military services and other defense agencies, particularly, but not exclusively in fields related to chemical warfare. (From Art. II, AFCA Constitution.)

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THE WHITE HOUSE

WASHINGTON

February 19, 1957

ARMED FORCES DAY:

This is the day, set aside for the past eight years, to salute our fellow citizens serving in the Armed Forces of the United States.

We have provided our military personnel with the finest equipment and training in the world, but it is equally essential for them to know they have our respect and appreciation.

It is a privilege to join in honoring them and I urge all citizens, wherever the limits of time and distance permit, to take part in the observance of Armed Forces Day.

By arms, by work, and by spirit, it is the responsibility of each citizen to help in the defense of the national community.

Dwight Eisenhower

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ARMED FORCES DAY

★ ★ ★ ★ ★ ★ ★ ★

The tenth anniversary of military unification and the fiftieth anniversary of military aviation will be keynoted in the 1957 observance of Armed Forces Day, May 18.

Both anniversaries are teamed under POWER FOR PEACE which has been the Armed Forces Day slogan since it was first used in 1953.

Military aviation was established on August 1, 1907 in the Aeronautical Division of the Office, Chief Signal Officer, U. S. Army. Naval aviation dates from its first aircraft order May 8, 1911. The U. S. Air Force was established as an independent Department in 1947.

It was on September 17, 1947 that James Forrestal took office as the first Secretary of Defense and thus inaugurated the new era in the overall direction of U. S. Armed Forces.

"Open house" for the public at posts, camps and stations, with demonstrations, parades, exhibits and other special features is provided for in the programs this year in some 3,000 communities.

12TH ANNUAL MEETING PROGRAM COMPLETE

The Hon. Gordon Gray, newly appointed Director of the Office of Defense Mobilization, to be Banquet Speaker May 23 at Sheraton-Park Hotel, Washington, D.C.; All three armed services to participate in the three-day session; 1957 marks the Golden Anniversary of the Air Force, Host Service for this meeting.

—U. S. Army Photo.

Banquet Speaker
THE HON. GORDON GRAY

The Honorable Gordon Gray, who is to be the Special Guest of Honor and speaker at the Banquet of the 12th Annual Meeting of A.F.C.A., Sheraton Park Hotel, May 23, was just recently appointed Director of the Office of Defense Mobilization by President Eisenhower. He succeeds Mr. Arthur S. Flemming, who recently resigned from that post in the Executive Office of the President.

In accepting this new post in the government, Mr. Gray resigned from his last previous position as Assistant Secretary of Defense (International Security Affairs) which he had held since July 14, 1955.

Mr. Gray served as Secretary of the Army in the administration of President Truman, resigning April 13, 1950 for other government duty as Special Assistant to the President, to study and report on the foreign economic policy of the United States. Upon conclusion of that work, he assumed his position as President of the University of North Carolina, to which he was elected in February 1950. Mr. Gray is himself a graduate of that University; received his Bachelor of Arts degree there in 1930. He attended the Yale Law School, and practiced law in New York City and later in Winston-Salem, N. C. He became President of Piedmont Publishing Co., and publisher of the Winston-Salem Journal and the Twin City Sentinel.

In 1939 Mr. Gray was elected to the North Carolina State Senate and was re-elected in 1941. In May 1942 he resigned his Senate seat to volunteer for military service; was inducted in the Army as a private and separated in 1945 as a Captain. He served overseas in the Headquarters of the 12th Army Group, commanded by General Omar Bradley.

Mr. Gray was born in Baltimore, Maryland, on May 30, 1909.

To Preside

—Parade

MR. GLENN A. HUTT
President of A.F.C.A.

To Welcome AFCA

—U.S. Air Force Photo

MR. RICHARD E. HORNER
Acting Asst. Secretary of the Air Force (R & D)

General Chairman

—Hessler Studio

MR. OLIVER F. JOHNSON
Vice President of A.F.C.A.—Meetings

LETTERS OF GREETING FROM SERVICE SECRETARIES

DEPARTMENT OF THE ARMY
WASHINGTON

28 March 1957

Dear Mr. Hutt:

It is with great pleasure that I extend cordial greetings, and a personal welcome to the Armed Forces Chemical Association on the occasion of its 12th Annual Meeting. The slogan for this meeting, "Setting the Sights for Industry," is most aptly chosen.

As scientific technology advances, future periods of National Emergency will find the Army even more dependent on the great chemical and related industries of this Nation than it has been during past emergencies. Although I note that this meeting is primarily sponsored by the Department of the Air Force as "host-service," I am glad that the Army, as well as the Navy, will have an opportunity to present many of their problems to you. Such meetings are essential for setting our mutual "sights" on our common goal of National Security. They also serve to indicate how the Armed Forces can use the help of your Association.

The Army's Chemical Corps will logically occupy a large share of your interest and time at this meeting, because of its essentially tri-service mission and responsibilities. I also am glad to know that a classified session will be included. I sincerely hope such a session will be extremely profitable and that we may have the benefit of your critical comments on it.

I wish you and your members a most pleasant and mutually profitable convention. In the meantime, I send you my kind regards.

Sincerely,

Wilber M. Brucker

Wilber M. Brucker
Secretary of the Army

Mr. Glenn A. Hutt, President
The Armed Forces Chemical Association
2025 Eye Street, N. W.
Washington 6, D. C.

—U S. Air Force Photo
DONALD A. QUARLES*
Secretary of the Air Force

DEPARTMENT OF THE AIR FORCE
WASHINGTON

OFFICE OF THE SECRETARY

MAR 29 1957

Dear Mr. Hutt:

On behalf of the Department of the Air Force I send warm greetings to the members of the Armed Forces Chemical Association and best wishes for a constructive Twelfth Annual Meeting. I feel that your slogan, "Setting the Sights for Industry," is a particularly appropriate one in view of your emphasis on research and development this year.

We in the Air Force recognize the many distinguished contributions to the national security being made by the many organizations represented in your Association and we are honored to be your host this year.

May the years that lie ahead be as productive to the nation as those that you have behind you.

Sincerely,

Donald A Quarles

Mr. Glenn A. Hutt, President
Armed Forces Chemical Association
408-410 Park Lane Building
2025 Eye Street, N. W.
Washington 6, D. C.

—U. S. Army Photo
WILBER M. BRUCKER
Secretary of the Army

(*Mr. Quarles was recently appointed Under Secretary of Defense.)

12TH ANNUAL MEETING PROGRAM

THE FULL PROGRAM for A.F.C.A.'s 12th Annual Meeting, May 22-23-24, in Washington, D.C., with headquarters at the Sheraton Park Hotel, is presented in this issue of the Journal.

Concentrated largely on chemical and allied problems involved in developing new or improved materials for national defense, the meeting has as its slogan—"Setting the Sights for Industry." It is probably the most extensive and strictly professional of any which the Association has yet had at its annual gatherings.

The "Host Service" is the United States Air Force, this year being its turn for that function, in accordance with the established practice of the Association to so call upon one of the three Services for each annual meeting. Accordingly, a considerable part of the program this year is provided by the Air Force. However, very substantial portions of the available time are allotted also for overall Army and Navy presentations. Moreover, in the case of the Chemical Corps of the Army, the parent organization of A.F.C.A., a full afternoon is provided to its participation. This will include introduction to the meeting by Maj. Gen. William M. Creasy, Chief Chemical Officer, of his principal staff and command assistants, namely: Col. William E. R. Sullivan, Deputy Chief; Dr. Per K. Frolich, Deputy Chief Chemical Officer for Scientific Activities; Mr. Edgar A. Crumb, Executive Director; Brig. Gen. Marshall Stubbs, Materiel Command; Brig. Gen. William R. Currie, Planning and Doctrine; Brig. Gen. J. H. Rothschild, Research and Development Command; Col. William J. Allen, Jr., Engineering Command, and Col. John M. Palmer, Training Command.

The official address of welcome from the Air Force, as the Host Service to the Association, will be made by Acting Secretary of the Air Force, Mr. Richard E. Horner.

Lt. Gen. Thomas S. Power, Commander of Air Research and Development Command will address the meeting on May 23 in introduction of the Air Force part of the program.

In all, the first two days of the meeting, with 20 speakers on as many subjects, constitute, themselves, a program of unusual interest and extent.

U.S. Army Photo
Col. Wm. E. R. Sullivan

No small part of the planning and co-ordinating for A.F.C.A's 12th annual meeting has fallen to the lot of the Army Chemical Corps which for its own presentations has a substantial part of the program. Heading up this work of the Corps, which involves a number of its major sub-divisions, is Colonel William E. R. Sullivan, Deputy Chief Chemical Officer. Colonel Sullivan is known to many of the Association's members. A native of Boston, he has a degree in chemical engineering from Northeastern University there and is also a graduate of Harvard School of Business Administration and the Armed Forces Industrial College. He served in World War II in the Corps of Engineers; commanded the 251st Engineer Combat Battalion in the European Theatre.

For the annual banquet at the Sheraton Park Hotel, The Hon. Gordon Gray, Director of the Office of Defense Mobilization, is to be the guest speaker. Entertainment will be provided by Air Force specialists. The banquet is placed on the night of the second day of the program, May 23, and concludes the unclassified part of the meeting. This will enable all those visitors who are not attending the classified meeting on the third day to depart promptly, avoiding for them a day's delay which would otherwise be occasioned.

On the third day those members and special representatives of Industry, who already have security clearances at the level of SECRET or above, and which have

(Continued on page 10)

U.S. Air Force Photo
Lt. Col. S. K. Moats

PROJECT OFFICER

Lt. Colonel Sanford K. Moats, assigned by the Air Force as Project Officer in connection with A.F.C.A.'s Annual Meeting this year, is a World War II Fighter Ace. Col. Moats has worked diligently with Mr. Oliver F. Johnson, A.F.C.A. vice president, and with the Association headquarters staff on arrangements for the meeting.

Colonel Moats was born in Kansas City, Mo., attended high school in Mission, Kansas, and joined the Air Force from Kansas State College, completing his pilot training in 1943.

He served in both the European and Pacific Theaters of Operation during World War II.

While a fighter-pilot in 1944 with the 8th Air Force in England, he was credited with 8½ aerial victories against the Nazis. In 1945 he transferred to the Pacific Theater.

Among Colonel Moats' assignments after World War II was that of Commander of the 91st Fighter Bomber Squadron in the United Kingdom. He is presently assigned to the Office of Information Services, Office of the Secretary of the Air Force.

Colonel Moats decorations include the Distinguished Service Cross, the Distinguished Flying Cross with Oak Leaf Cluster and the Air Medal with 11 Oak Leaf Clusters.

AFCA 12th ANNUAL MEETING PROGRAM

Sheraton Park Hotel—Washington, D.C.

May 22-23-24

Theme: "Setting the Sights for Industry"

Service Host: U. S. Air Force

PROGRAM

MAY 22—Wednesday (Unclassified)

Opening Session

9:00 AM-12:45 PM—Registration
9:00 AM-12:00 Noon—Coffee
10:00 AM-12:00 Noon—Board of Directors Meeting
1:00 PM- 2:00 PM—General Meeting with official Air Force Welcome by Mr. Richard E. Horner, (Acting) Assistant Secretary of the Air Force (Research and Development)

Afternoon Session—Army Chemical Corps Presentations

2:00 PM- 2:20 PM—*Address*
Maj. Gen. Wm. M. Creasy
Chief Chemical Officer

2:20 PM- 2:30 PM—*Introduction of Key Chemical Corps Personnel*
Maj. Gen. Wm. M. Creasy
Chief Chemical Officer

2:30 PM- 2:35 PM—*Introduction of Research and Development Command Program*
Brig. Gen. J. H. Rothschild
Commanding General
Chemical Corps Research and Development Command

2:35 PM- 2:55 PM—*Role of Industry in the Search for New Toxic Agents*
Dr. Edward A. Metcalf
Chemical Warfare Laboratories

3:00 PM- 3:20 PM—*Development of Specialized Safety Equipment in Conjunction with BW R&D Program*
Dr. Arnold G. Wedum
Safety Director
Biological Warfare Laboratories

3:20 PM- 3:40 PM—*Break*

3:40 PM- 4:20 PM—*Army Chemical Center and Chemical Corps Materiel Command Procurement Skit*
Brig. Gen. Marshall Stubbs
Commanding General
U. S. Army Chemical Center and Chemical Corps Materiel Command

4:20 PM- 4:40 PM—*Chemical Corps Engineering Command Program*
Col. William J. Allen, Jr.
Commanding Officer
Chemical Corps Engineering Command
A. *Establishment of Associate Project Engineer Concept*
B. *Surveillance Data Evaluation*

Evening Session

6:30 PM- 7:45 PM—*Reception* (With Air Force String Ensemble)

(Evening left open for Company parties or other plans)

MAY 23—Thursday (Unclassified)

Morning Session—Air Force Presentations

Col. W. A. Williams, Chairman for the Air Force program, presiding.

9:00 AM- 9:10 AM—*Introductory Remarks*
Lt. Gen. Thomas S. Power
Commanding General
Air Research and Development Command (ARDC)

9:10 AM- 9:30 AM—*Mission and Functions of ARDC*
Lt. Col. Carlo R. Tosti
Assistant Executive to General Power, ARDC

9:30 AM-10:10 AM—*"How to Get to Us"*
Mr. Warren Baker
Plans, ARDC

10:10 AM-10:50 AM—*"Proprietary Rights"*
Mr. P. Sherwood
Chief, Patents Division
Judge Advocate General, ARDC

10:50 AM-11:10 AM—*Break*

11:10 AM-11:40 AM—*Technical Program Planning Documents*
Col. William A. Williams
Assistant to Brig. Gen. Marvin C. Demler, Deputy Commander for Research and Development, ARDC

11:40 AM-12:00 Noon—*Toxicological Warning Systems*
Col. Jack S. Carmichael, USAF, MSC, Chief Engineering Branch and Chief Environmental Health Laboratory Branch, Office of the Surgeon, Hqrs., AMC
Capt. Robert T. P. DeTreville, USAF, MC,
Deputy Chief Medical Specialties Branch, Office of the Surgeon, Hqrs., AMC

12:00 Noon- 1:00 PM—*Break*

Afternoon Session—Army Presentations

1:00 PM- 1:10 PM—*Introduction*
Maj. Gen. J. P. Daley
Director of Special Weapons
Office of the Chief
Research and Development

1:10 PM- 2:50 PM—*The Importance of General Scientific Investigations and Basic Research to the U.S. Army*
Dr. R. Rollefson
Chief Scientist, U.S. Army -and
Brig. Gen. T. J. Conway
Director of Research, Office of the Chief, Research and Development

2:50 PM- 3:10 PM—*Break*

Navy Presentations

3:10 PM- 5:00 PM—Chairman for the Navy Program, Dr. L. W. Butz, Head of the Chemistry Branch, Office of Naval Research
A. *Problems in Preserving or Improving Materiel and Equipment.*

Commander A. B. Chilton, USN
Manager of Atomic Energy Branch
Research Division, Bureau of Yards & Docks
B. *Current Bureau of Ships Problems on Materiel Development*
Captain B. F. Bennett, USN
Bureau of Ships
C. *Chemistry, Present and Future, for Naval Aircraft*
Mr. F. P. Somers
Bureau of Aeronautics

Evening Program

6:30 PM- 7:45 PM—*President's Reception*

7:45 PM- —*Grand Banquet*
Guest Speaker:
The Honorable Gordon Gray
Director, Office of Defense Mobilization
Entertainment:
Reception: Air Force Jumping Jacks
Banquet: Air Force Strolling Strings, Singing Sergeants, Bagpipes and String Ensemble

MAY 24—Friday (Classified)

(Each person attending the classified meeting will be required, after registration and before boarding the bus for Andrews Air Force Base, to show his official written authorization to attend this meeting, which was sent him by mail by the Security Agency)

7:00 AM- —Board Busses at Sheraton Park Hotel for Andrews Air Force Base (Police Escort)

8:00 AM- 8:30 AM—*Coffee and Doughnuts*
At Exhibit Area

Morning Session—Air Force Presentations

8:30 AM- 8:40 AM—*Introductory Remarks*
(Brig. Gen. Marvin C. Demler, Deputy Commander for Research and Development ARDC, presiding.)

8:40 AM- 9:20 AM—*Aeronautics and Propulsion Problems and Requirements*
Lt. Col. R. T. Helmsley
Chief, Propulsion Branch, Aeronautics and Propulsion Division, ARDC

9:20 AM-10:00 AM—*Materials Problems and Requirements*
Lt. Col. R. A. Jones
Chief, Materials Branch, Materials & Equipment Division, ARDC

10:00 AM-10:40 AM—*Air Force Evaluation BW-CW Munitions*
Dr. K. A. Krieger
Big Ben, ARDC

10:40 AM-11:20 AM—*Human Factors Problems of Flight in the Future*
Lt. Col. A. A. Taylor
Assistant Chief, Aero-Medical Branch, Human Factors Division, ARDC

11:20 AM-12:00 Noon—*A Look Into The Future*
Dr. Amos G. Horney
Director of Material Sciences, Air Force Office of Scientific Research

12:00 Noon-1:30 PM—*Lunch at Exhibit Area*
(Nominal charge by Officers Mess)

1:30 PM- 1:50 PM—*Thunderbirds*
Demonstration by U.S. Air Force acrobatic precision flight team

Afternoon Session—Navy Presentations
(Dr. Butz presiding)

2:00 PM- 3:30 PM—A. *Shipboard Aviation Fuel Contamination and Other Current Bureau of Ships Problems*
Commander C. M. Sturkey, Jr., USN, Bureau of Ships
B. *Problem Areas In Explosives Systems*
Dr. W. E. Land
Bureau of Ordance
C. *Chemical Problems in the Propellant Fuels*
Mr. Elliot Mitchell
Bureau of Ordnance
D. *Chemistry, Present and Future, for Naval Aircraft*
Dr. H. W. Gilbert
Bureau of Aeronautics

Army Presentations

3:50 PM- 4:30 PM—*Future Concepts of Land Combat*
Col. S. O. Fuqua
Deputy Director, Organization and Training, Office Deputy Chief of Staff for Operations

4:30 PM- 4:35 PM—*Break*

4:35 PM- 5:05 PM—*Development of Materiel to Meet Requirements for Future Land Combat*

A.F.C.A. 12TH ANNUAL MEETING CHARGES

General Registration and all events, per person	$20.00
Reception and Banquet for guests of those who are registered, per person	15.00
Military Personnel in Uniform:	
General Registration and all events	15.00
Guests of registered military personnel for Reception and Banquet on May 23 only	10.00
Ladies' Program:	
Separate charge for special luncheon, per person	3.50

* * * * *

Classified Meeting—Andrews AF Base May 24:

Each person attending the classified meeting will be required, after registration and before boarding the bus for Andrews AF Base, to show his official written authorization to attend this meeting, which was sent to him by mail by the Security Agency.

PROGRAM—Cont'd

Brig. Gen. C. B. DeGavre
Director of Developments, Office of the Chief, Research and Development

5:05 PM- 5:20 PM—*Discussion*
5:30 PM- —Board Buses to Hotel

LADIES' PROGRAM

MAY 23—Thursday

(Chairman of Ladies' Program Committee, Mrs. Momsen, wife of Vice Admiral Charles B. Momsen, USN-Ret.)

9:30 AM-12:00 Noon—Bus tour of Washington with stops for visits to: The White House; The Freer Art Gallery; Smithsonian Institution, to see display of Inaugural Ball dresses worn by wives of Presidents, and special glassware exhibits.

12:00 Noon- —*Luncheon* at Officers' Club, U.S. Naval Gun Factory; Musical feature by Air Force players
Afternoon visit to National Art Gallery, The Capitol, and tea at the Spanish Embassy

12TH ANNUAL MEETING

(Continued from page 7)

been verified especially for this meeting, will proceed by special transportation to Andrews Air Force Base, leaving the hotel at 7 A.M.

Each person attending the classified meeting will be required, after registration and before boarding the bus for Andrews AF Base, to show his official written authorization to attend this meeting, which was sent him by mail by the Security Agency.

Breakfast coffee and doughnuts and also luncheon will be served at the area where the meetings at Andrews AF Base are conducted. In connection with the presentations there by speakers from all of the three armed services, there will be classified exhibits of equipment and materiel.

By way of special interest and diversion from the program of technical discourses, the Air Force is providing a demonstration by its famous acrobatic precision flight team, the "Thunderbirds." This organization has lately been equipped with North American F-100 Super Sabre Jet fighter aircraft. (See front cover picture).

The occasion of this annual meeting is one for a two-fold congratulation by the Association to the Air Force. Not only is the Air Force the Host Service, but, this year marks the 50th, or Golden, Anniversary of military aviation as a major element of our defense forces. As noted elsewhere in this issue, celebrations of the Air Force Golden Jubilee Anniversary are scheduled throughout the country as part of Armed Forces Day programs on May 18.

The General Chairman of the meeting this year is Mr. Oliver F. Johnson, Vice President for Meetings.

Members and guests attending will each receive a copy of a specially illustrated Souvenir Program, which is being prepared by the Program Publication Committee, headed by Col. Robert T. Norman, also a Vice President of A.F.C.A. Other members of this committee include Maj. Gen. Charles E. Loucks, USA Retired, and Lt. Col. Sanford K. Moats, USAF.

The Program Advertising Committee is headed by Col. Harry A. Kuhn, a past-President of the Association.

The Ladies' Program Activities Committee is headed by Mrs. Momsen, wife of Vice Admiral Charles B. Momsen, USN, Retired, Chairman. Other members are: Mrs. Oliver F. Johnson, Mrs. John C. MacArthur and Mrs. Charles Pledger.

The extensive job of Registration, Welcome and Physical Property Arrangements for the meeting is charged to a committee headed by Mr. Don MacArthur, of Washington Chapter.

Lt. Gen. Thomas S. Power

ARDC COMMANDER

THE EXTENSIVE and far-flung research and development organization of the Air Force, known as ARDC, is commanded by Lt.Gen. Thomas S. Power. General Power is on the program of A.F.C.A.'s 12th Annual Meeting. Born in New York City in 1905, he entered the Service as a flying cadet and was commissioned in the Air Corps Reserve in 1929. In World War II, having then been promoted to colonel, General Power's first overseas assignment was as deputy commander of the 304th Bomb Wing in the North African theatre of operations. Later he was placed in command of the 314th Bomb Wing which was moved to Guam and became part of the 21st Bomb Command. In August 1945 General Power joined the U.S. Strategic Air Force in the Pacific and was assigned as A-3 during the atomic bomb attacks on Japan. Subsequent assignments, with promotions to brigadier and major general, included participation in the atomic bomb tests, after the war, at Bikini; deputy assistant chief of staff for operations at Army Air Force Headquarters, Washington, D.C. (before the integration of the services) and Air Attache in London. In May 1954 having been promoted to lieutenant general, he was assigned in command of ARDC. General Power has been awarded the Distinguished service Medal and numerous other decorations.

AIR RESEARCH AND DEVELOPMENT —KEY TO SUPREMACY AND SURVIVAL

How ARDC Focuses Technology on Air Force Weapons

Air Weaponry Today, More Than At Any Other Period in U.S. History, Depends Upon Scientific Progress For Answers To The Future Development of Air Weapon Systems.

By COLONEL LESLIE B. WILLIAMS, USAF
Director of Research
Air Research and Development Command

Why Air Research and Development

Napoleon probably was the first military man to combine chemical materiel requirements of warfare with scientific research.

Dependent upon West Indian sugar for his troops, he prevailed upon French botanists to breed a strain of beet sugar that would be available nearby and in quantity.

Later, he encouraged chemists to develop a process by which foods could be kept almost indefinitely. Chemists failed the diminutive Corsican. But Nicolas Appert, a brewer and distiller, developed a crude system of conserving food by sterilization through heat and hermetically sealing the containers to prevent contamination. Appert later was awarded 1,200 francs for his work by a grateful government.

Ever since, military men have called upon chemists and scientists from many other fields to help them improve the *art* and *science* of war. For a long period results were not too impressive. But in recent years, soldiers and scientists have combined their efforts to achieve phenomenal success.

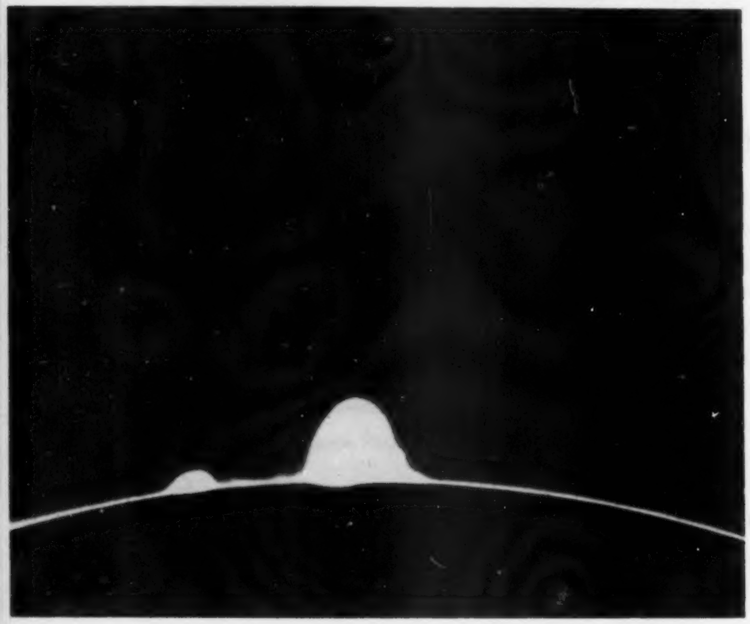
During the past decade, world attention has focused on the all important role that scientific and technological progress has played in revolutionizing military weaponry and its effects on the power of nations.

Single nuclear weapons with more destructive power than the sum total of explosives dropped by all participants during World War II; globe girdling jet aircraft; rockets and guided missiles of uncanny and incredible accuracy; planes that push past the sonic "barrier" as they streak through the stratosphere at supersonic speeds; pilots who plunge to earth from heights of 43,000 feet and higher as they test new equipment; and threats of missile bombardment—all these facts have been duly dramatized in the world press.

Yet, little known and less realized is the fact that the seemingly fantastic progress made in the production of military weapons represents the end results of a long process of research and development which have involved universities, industry, military planners, and scientists in all fields ranging from aeronautics to zymurgy. Yes—our progress is a far cry from Napoleon's example to the system that produces our modern weapons!

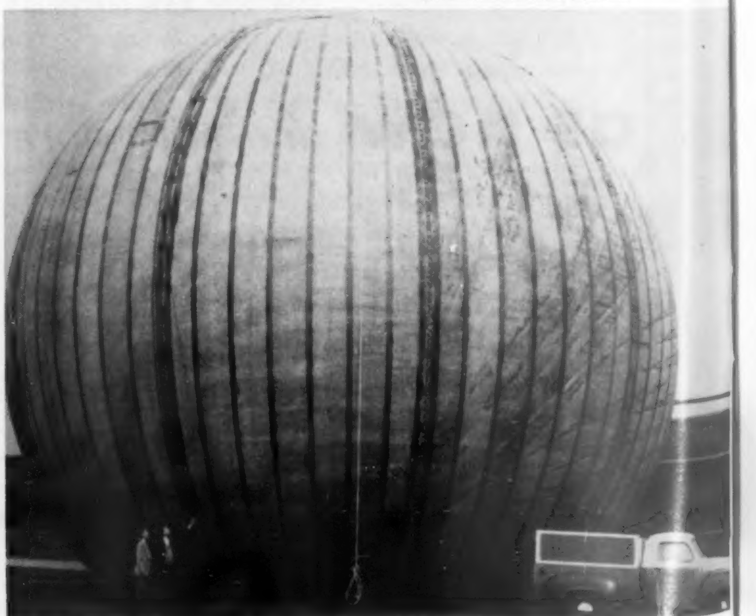
CHEMISTRY OF UPPER AIR. As the microwave spectroheliograph's dish antennae scan the sun's surface, the "Chromosphere," hitherto mysterious billowing layers of incandescence known as sun spots, can be seen. The layers rise to heights of 6,000 miles above the surface of the sun.

—U. S. Air Force Photo



CHEMISTS CONTRIBUTION. Composed of identical sections of neoprene-coated nylon fabric, this jumbo-sized beach ball is really the world's largest air-supported radome. Radomes such as this one are used to protect radar antennae against adverse weather conditions. Measuring 61 feet in diameter, it dwarfs the two men and a truck seen at the base of the radome.

—U. S. Air Force Photo.



Today, more than at any other time in its history, the United States must be concerned with the research and development of modern military weapons. (Not always have we been so fortunate and farsighted.) A brief history of research and development in the United States will enable *Armed Forces Chemical Journal* readers better to understand our present approach to this most important of Air Force peacetime military plans and programs.

Prior to World War I, military men thought in terms of the mass movement of men and materiel by land and sea. In 1914, for instance, Federal appropriations for aeronautics totaled a miniscule $125,000. The amount placed the United States 14th among the nations of the world in amounts appropriated for that purpose.

During the six-year period from 1908 through 1913, the United States spent but $435,000 for aeronautics. By way of comparison, Germany spent $28-million during the same period, leading the world's nations in this field. France was second with $22-million; Russia ranked third with $12-million; and Great Britain followed in fourth place with $3-million.

Shortly after the outbreak of World War I, interest in aviation increased throughout the world.

After World War I, U. S. military interest in aviation waned, rose, wavered, and waned again. At the outbreak of World War II, the United States found itself not too well prepared aeronautically.

Prior to 1939, however, the Germans had moved into jet engine research, and led the world in the guided missile field.

Yet, United States interest in guided missiles was not exactly dormant. But it was not until after the Germans had succeeded in launching the V 2 that we concentrated in the research and development of these weapons.

After World War II, air research and development in the United States continued apace. New pathways in radio, radar, infrared and other electronic areas were probed by scientists. Planes of fantastic speeds (more than 1,600 miles per hour) were flight tested and scheduled for the United States armament inventory. Missile research has become a national pre-occupation. They give promise of becoming tomorrow's most revolutionary air weapons.

Meanwhile, a gaunt, grey ghost looms on the horizon. The grave concern of U. S. military men is that although we record rapid research and development progress, so do the Soviets.

Never a warring nation, United States military strength is not maintained for aggression. The fundamental objective of the Air Force's research and development effort is to achieve and maintain such qualitative superiority of its weapons that any aggression would be costly and foolhardy. More specifically, the quality of the Air Force's weapons must always remain so decisively superior to those of any potential enemy as to permit effective retaliation and also insure effective defense against aerial attack.

In combination, absolute and recognized qualitative supremacy in both defensive and retaliatory weapons represents a powerful deterrent to aggression which, in essence, is the primary purpose of our entire military effort, and especially that of research and development.

Centralizing Air Research and Development

A short time after World War II, United States military men realized that the country's lead in military technology was dwindling; had, in fact, been dwindling steadily since the world's first atomic bomb burst over Hiroshima on August 6, 1945.

Four years later, for instance, the Soviets successfully detonated their own atomic bomb.

During 1948-50, the Soviets telescoped time in the research, development and production of the jet engine. Thus they started closing the technological gap that previously had existed to a marked extent between the East and the West.

Realization of this fact resulted in a series of studies which were conducted by Air Force officers and military and civilian scientists. The studies revealed a need for centralized research and development management under a single organization with strong central command and leadership.

In order to insure this strong central command and leadership for air research and development activities, the United States Air Force consolidated all of its research and development, and established the Air Research and Development Command (ARDC) on January 23, 1950. Command headquarters are now located in Bal-

Colonel Leslie B. Williams

The author of this article is Director of Research in the Air Research and Development Command. Born in Kinston, North Carolina, in 1914, Colonel Williams has a B.S. degree in Chemical Engineering from North Carolina State University, and a M.S. degree in Physics from the University of North Carolina. He has done graduate work in Electronics and Physics at Harvard, MIT, the Naval Post Graduate School and the University of Pennsylvania.

Commissioned in the Infantry Reserve in 1935, Colonel Williams, during World War II, commanded an aircraft warning unit in the Pacific Theater; later served there as Radar and Communications Officer of the 13th Air Force. His service since the war includes five years as Chief of the Aeronautical Research Laboratory, WADC. His civilian experience includes seven years as Research Engineer and Physicist with a petroleum refining firm.

timore, Maryland. Lieutenant General Thomas S. Power is the ARDC commander.

Less than two years after ARDC was established, the United States received proof positive the Soviets were fast bridging technological gaps that had previously existed.

In 1952, the United States reported the detonation of its first thermonuclear weapon. A scant year later, the Soviets duplicated the feat. That same year, the Soviets brought out a new interceptor.

In addition, the Soviets scored remarkable progress in radio, radar, infra-red and other electronics fields. Only a short time ago, we began introducing the intercontinental B-52 bomber into the Air Force inventory. But on July 6, 1955, the Russians revealed the existence of a comparable plane—the Bison.

Such Soviet progress underscored a single grim fact: the gravest feature of the Soviet challenge was that its technology had achieved a momentum rivaling our own. Moreover, the Soviets can channel large segments of their national resources toward military goals. This constitutes the greatest military threat we have ever faced.

Now that the feasibility of harnessing nuclear firepower to the potential of long-range missiles is in sight, we must maintain absolute air supremacy over any potential enemy. Maintaining that supremacy is the main and continuing mission of the U. S. Air Force.

Today, ARDC functions as unique management tool to achieve and maintain qualitative air superiority for the United States.

To insure this air supremacy, ARDC draws upon the total technological potential of the nation. The Command with its centers works directly with industry, with educational organizations, and with government agencies for maximum results, within the limits of the research and development dollars available.

Some 80 percent of the Air Force's research and development effort is being contracted among nearly 200 universities, colleges, and other non-profit institutions, and some 1,500 industrial concerns.

Close cooperation with these research and development agencies is especially important to the Air Force. Being the youngest of the three Services, it has few establishments like the arsenals, gun factories, shipyards and other facilities already *in being* and maintained by the Army and Navy.

It is important to note, at this point, that ARDC is responsible for the entire spectrum of aerial weapon systems development—from basic research, aimed at advancing our fundamental knowledge, to the development and testing of hardware.

At the research end of the spectrum, ARDC funnels its resources into those broad areas of science most likely to pay off for the Air Force. ARDC research seeks to provide, of course, fundamental understanding which will help solve problems already foreseen in connection with weapons on the drawing boards, but even more important, to maximize the chances for entirely new military concepts or major breakthroughs which are potentially present in scientific advances.

In this area, for instance, ARDC's Air Force Office of Scientific Research is given over entirely to contracting with scientific institutions and universities for research programs. Other ARDC centers as well, engage in the research program both through contracts and in the laboratory programs. The ARDC's European Office in Brussels, Belgium, taps the scientific potential of Europe so that it may be integrated into the research program of ARDC via its center programs.

Intermediate in the spectrum, we have an example of a unique weapon system management organization. The

(Continued on page 34)

POLYMER CHEMISTRY

New polymers hold great promise for the future development of high-temperature structural materials, non-flamable lubricants and hydraulic fluids, and new types of synthetic rubber.

The ARDC research program in polymer chemistry can be summarized into three chemical families: fluoro-elastomers, modified silicones and inorganic polymers. Intrinsic to each area are studies attempting to track down the mechanisms of polymerization and the reasons for the molecular stability of the resulting polymer.

FLUORO-ELASTOMERS—Research is being conducted on fluorine containing silicones and fluorine containing dienes and olefins.

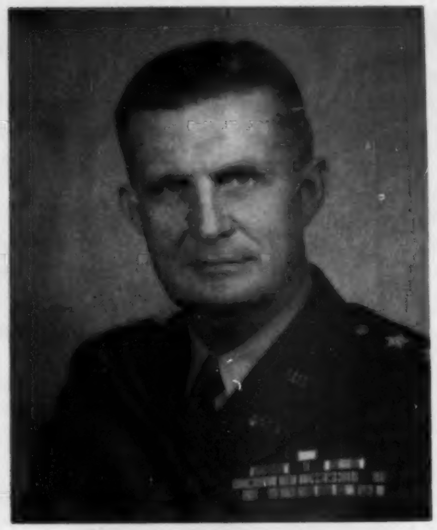
MODIFIED SILICONES—The basic silicone molecules are being studied through the introduction of selected fluoro-alkyl groups in the side chains.

INORGANIC POLYMERS—Several systems are under study in an attempt to produce entirely new types of polymers—ones in which phosphorus, selenium, germanium, zinc, boron or sulfur substituted into the polymer chain.

MISSILE BLASTOFF. Shown here is the X-17, an Air Force test missile, as it blasts off into space from its test base somewhere in Florida. The missile hurtles into the ionosphere, then plummets down into the earth's heavy blanket of air at supersonic speeds. Chemists make major contributions toward researching ideal fuels for these unmanned space vehicles.

—U. S. Air Force Photo.

Grasshopper fossil of the Jurassic Age, 140 million years ago.
Photo courtesy American Museum of Natural History, New York



Maj. Gen. William M. Creasy

WOULD CBR STRENGTH AID IN DETERRING WAR?

By **Major General William M. Creasy**
Chief Chemical Officer

(A talk before the National Military-Industrial Conference in Chicago, Ill., March 14, 1957, sponsored by the Society of American Military Engineers and Co-operating Agencies, including Midwest Chapter, A.F.C.A.)

Part of Webster's definition of an engineer is: "One who carries through an enterprise by skillful or artful contrivance . . ."

Among the prerequisites for a good engineer is an ability to show imagination in planning and celerity in thought; an ability to consider a situation analytically and dispassionately. An engineer must be able to judiciously consider his tools at hand, and wisely decide how they will be used, either singly or in conjunction with each other, to attain the over-all objective.

Today, our national security policy has as its central aim the deterrence of Communist expansion in whatever form it may take to the end that it will not constitute a threat to the security of our nation. We must have the political, military, economic, and moral strength sufficient to induce the Communist Bloc to renounce or refrain from all forms of aggression against the Free World. And, the evidence of this strength must be so clear as to create in the mind of any potential enemy the conviction that aggression will not pay—that there will be no profit—and so bring about conditions leading to a true world peace.

The elements of a sound national security program must include adequate provision for four things: deterrence of general war, deterrence of local aggression, defeat of local aggression, and, if necessary, victory in general war conducive to a viable peace. And, always in our minds must be the realization that in spite of all our efforts at deterrence, general war may occur and last for an indefinite period.

In other words, while we all work and pray for peace, we must not lose sight of the realistic fact contained in the words of George Washington who said, in 1790, "To be prepared for war is one of the most effective means of preserving the peace." This thought most certainly still holds true.

We might consider the situation in the light of our own personal experiences. For instance, there have been many times when, for some reason or other, we have put off doing something until "tomorrow"—and "tomorrow" never seems to arrive. As a result the particular thing does not get done.

Isn't it just possible that our strength to meet, and defeat aggression, may cause the would-be aggressor to put off his intentions until "tomorrow," just like we as individuals have done? And isn't it just possible that while the aggression is being deferred until the "right time," the forces for peace may have become so strong that the aggressor's plans eventually bog down and are never carried through? It's a thought.

Now, as engineers, what "tools" do we have to accomplish the great enterprise in which we are engaged?

First, there is the maintenance of a military technological superiority over the Communist Bloc—the weapons of war, and our means of defending against them if they are used on us. Second: a deterrent munitions delivery system capable of effective retaliation against an enemy—an ability to use our military technological superiority, if necessary. Third: the proper training and disposition of our human resources to do the job for which they are best suited—our manpower reserve. Fourth: the production of those things needed for military strength—our industrial capability. Fifth: the ability to settle international differences through the written or spoken word—diplomacy. Sixth: the recognition that man has certain inherent rights—our moral convictions. And seventh: a realization that we, you and I, our friends and families, are potential targets of an enemy—mental conditioning.

For the next few minues let's discuss the role of one set of tools in our job of engineering total peace. I refer to the Chemical, Biological, and Radiological munitions.

Our consideration of these agents of warfare will be in the light of "would CBR strength aid in deterring war?"

The generic term "toxic" or "toxicological" warfare is quite often applied to the fields of Chemical, Biological, and Radiological Warfare, individually and collectively. For this reason these munitions are classified as weapons of minimum destruction as opposed to those weapons of maximum destruction which attack not only living things but destroy material objects as well.

So that we will all be thinking along the same lines, let's very briefly consider their nature and characteristics and the features which might make them desirable for use by an enemy.

Within the framework of the over-all elastic term of "chemical warfare" are included the military use of toxic chemical compounds, flame warfare, incendiary materials, and the use of signalling or obscuring smokes. However, during the next few minutes, when I mention the words "chemical warfare" I will be referring only to the toxic chemical compounds—war gases.

These war gases are of several types. Some merely cause crying or nausea for short periods of time and are

(Continued on page 26)

CHEMISTS CHALLENGED TO FIND SOIL SOLIDIFIER

A CHEAP MATERIAL which willl transform surface soil into a hard pavement is among the strange substances urgently sought by the armed services, according to the National Inventors Council, U. S. Department of Commerce.

The soil additive is needed to harden up access roads, bridge approaches, sandy beaches and missile launching sites, where rocket blast causes temporary dust storms. The material must prove easy to mix and apply to wet or dry soil without using complicated heavy equipment.

"So far, a good cheap soil solidifier has eluded military research teams," said John C. Green, director of the Office of Technical Services and the Council's executive director. "But we're hopeful that independent civilian chemists can find the answer to this and other chemical problems."

The Council is the official clearinghouse for all inventions and formulas of potential value to the Government.

Snow Melter and Other Needs

On behalf of the Department of Defense, NIC is also seeking a chemical which will melt snow and ice when the thermometer drops to 65 degrees below zero. At present, the ice film left behind by snow plows on runways is melted off with calcium chloride, which unfortunately corrodes aircraft metals. Heated sand won't do the job at very low temperatures.

Other problems which might be cracked by free-lance chemists include:

Battery Conversion Method for Sub-zero Use. A simple, foolproof means of converting an ordinary auto storage battery for use at temperatures as low as 65 below. The answer might be a new electrolyte or additive with a low freezing point and satisfactory conductivity. The substance would have to be inorganic and harmless to the battery and compatible with sulfuric acid and its combinations with lead. It should not contain Epsom or Glauber's salts.

Coating for Skis or Ski Type Landing Gear. A light weight, easy-to-apply compound with a low coefficient of friction on all sorts of surfaces, excellent abrasion resistance and good adhesion to metal or wood. The versatile coating must neither freeze to ice nor absorb moisture.

New Method of Floating Sodium Fluorescin Dye. Some means of keeping this yellow dye from sinking too deep to be seen from the air. Used to mark people or objects adrift at sea, the dye tends to sink unless agitated near the water's surface. If the dye is treated to float on the water, on the other hand, it is too easily dispersed in choppy seas.

Scores of other military problems which challenge the talents of civilian chemists may be obtained by writing NIC, U. S. Department of Commerce, Washington 25, D. C. The Council evaluates written solutions to problems and forwards all promising ideas to appropriate military authorities.

A.F.C.A. members will recall Dr. Horney as the author of an article in the May-June 1954 issue of the Journal, "Chemistry Rides the Super Jet," which., along with others in that issue, signalized the 9th Annual Meeting of A.F.C.A., which, like the meeting this year, was also in Washington and with the Air Force also in the role of "Host Service."

Dr. Horney, born at Hortonville, Indiana, March 18, 1907, received an A.B. degree at Earlham College, Richmond, Indiana, in 1930; then attended Ohio State University, majoring in Chemistry and receiving there M.S., M.A., and Ph.D. degrees. He is a registered Chemical Engineer, member of numerous engineering and scientific societies, and author of a number of publications. He also holds several patents.

Dr. Horney has worked as a research chemist in industry, served as the head of the Chemical Department and Dean of Liberal Arts of the Associated Colleges of Upper New York. He has served in the Government in several important scientific positions and has been with the Air Force since April of 1949.

BEYOND THE MATERIALS BARRICADE

NEW FRONTIERS IN CHEMISTRY AND SOLID STATE

By Amos G. Horney

Director of Material Sciences
Air Force Office of Scientific Research
Air Research and Development Command

Increased Power in small packages has led to higher and higher velocities. The utility has been sapped out of our available materials. In a little over a decade the use of new power plants has multiplied the speed of flight by more than a factor of ten and generated the so-called thermal barrier. Only recently has the United States Air Force given serious consideration to fundamental studies of existing limitations in materials—materials for structures, power plants, electronic devices; materials for the comfort and safety of man.

Traditionally, the military has carried out its research and engineering by establishing requirements. As a requirement is broken down into the necessary bits and pieces, it is discovered that existing materials and techniques are not adequate and something better is necessary. This search for an improvement in answer to an assigned problem we will call *requirements' research*. A problem is presented; an answer is sought; the answer can be visualized as becoming contributory to military hardware.

The relatively sure but low pay-off of requirements' research has prompted the military also to engage in exploratory research—research with a promise of very high pay-off, even though the probability of sure success may be low. The ARDC's Air Force Office of Scientific Research has the assigned mission of sponsoring exploratory research of interest to the Air Force. Its program is not designed to provide specific new materials such as new alloys, new plastics, etc., but seeks to go beyond the realm of systematic knowledge and produce concepts or ideas beyond the frontiers of present science in areas which are judged to have potential value in fulfilling requirements not yet anticipated. There are other Air Force agencies which are more concerned with applying scientific concepts to recognized problems. While requirements are generated by weapons in being or anticipated, scientific problems are generated in clarifying scientific knowledge and in exploring new natural phenomena. New concepts are born in the minds of investigators. Since there is an overlap between the requirements and the exploratory approach, I would like to clarify the difference and to give you a feeling for AFOSR's exploratory research program in materials. Perhaps the best way to do this is by citing the accomplishments of several investigators in the Chemistry and the Solid State research programs.

Research Program Accomplishments

Along with the need to know how and why matter behaves as it does, goes the need for the tools and techniques for further study and for transforming the knowledge to useable form. Cooke, for example, has developed techniques in solution chemistry for detecting the presence of metallic ions in concentrations of one part in ten billion.

Researches in surface chemistry are underway to increase knowledge of the magnitude, distribution and nature of forces and energies at interfaces, and to gain an understanding of the mechanisms of catalyzed reactions. Emmett has designed a catalytic reactor which uses a gas chromatographic column to analyze the microquantities of reactants and products. The instrument should prove useful in studying the progress of reactions during the transient stages before the onset of equilibrium.

A major concern of the Air Force today is high temperature. A fundamental study of high temperature chemistry requires accurate temperature measurement. With this in mind, Broida, under AFOSR sponsorship, has developed a technique which makes use of strongly absorbed spectral lines to determine temperatures in flames. Recently, Grosse and associates developed flame temperatures with cyanogen and oxygen of 4800°K and with

carbon subnitride and oxygen of 5300°K. This group has also produced the first 100% ozone flame. (Note another article in this issue.)*

In its position at the threshold of space, the Air Force has ever-increasing reason to be concerned with photochemistry and the broader field of radiation chemistry. Our interests include the interconversion of radiant and chemical energy, and the chemical effects of the interaction of radiation with matter. LuValle has proposed a new theory of photographic development, based on certain structural relationships in the developers, which has led to the synthesis of several improved photographic developers. This work has progressed to the point that the staff of the Aerial Reconnaissance Laboratory wishes to exploit the discoveries. Kasha, through a spectroscopic study of the inter-combinations in molecules, has found an explanation for the role that the heavy atom plays in the photographic process.

That the limitations of materials retard progress in the aircraft and weapons program, no one denies. Needed is a knowledge of the general principles that govern such factors as thermal stability, reactivity and fatigue. To secure this knowledge we emphasized research in the areas of molecular configuration, intermolecular forces, structures of solids and liquids, surface reactivity, chemical bonding and adhesion. Novel synthesis studies have been encouraged. Gall has studied the physical properties of perchloryl fluoride, nitrogen trifluoride, liquid fluorine and other fluorine compounds. Perchloryl fluoride is a superior oxidant in bipropellant systems. In studying aqueous solutions above and around their critical temperatures, Corwin has discovered a new crystalline form of germanium oxide. This has been verified by x-rays.

Recent widespread interest in the possibilities of *"free radicals"* as propulsive fuels has confirmed our foresight in encouraging research in this area. The individual work of Wertz and Fraenkel has contributed much to the technique of identifying and studying the reactions of free radicals, using paramagnetic resonance techniques. Livingston, Noyes and Cross individually have contributed to the knowledge of their production and identification by photochemical techniques. Broida has investigated the properties of a number of relatively simple materials produced in an electric discharge and condensed on a liquid helium-cooled surface. He has successfully stabilized small quantities of atomic nitrogen, oxygen and hydrogen. Out of his studies has grown a million-dollar project, sponsored by the Department of Defense, for the study of the production, stabilization, and control of free radicals, with a view to their eventual use as fuels.

Harteck has shown that it is possible to catalytically control the recombination of atomic oxygen, and that the process could yield useful propulsive energy. An interesting aspect of his study is the idea of using the free supply of atomic oxygen stored in the upper atmosphere. After the preliminary stages of Harteck's work under the sponsorship of AFOSR, the interest of the Cambridge Research Center was aroused. In fact it was Harteck who sparked their much publicized experiment March 14, 1956 which resulted in the spectacular reaction between atomic oxygen and nitric oxide in the upper atmosphere.

Solid State Sciences concerns itself with the nature of imperfections in solids, how to control them, and their influence on the physical properties of solids. Among the various kinds of solids of special interest to the Air Force are metals, alloys, ceramic materials, semiconductors, ferrites and dielectrics. The kinds of imperfections being investigated in these solids include phonons, electrons and holes, excitons, vacant lattice sites and interstitial atoms, foreign atoms in either interstitial or substitutional positions, and dislocations.

For some years it has been generally believed that the surfaces of a material are important factors in deciding what properties the bulk will exhibit. Tools to examine surfaces have constantly been sought. X-ray diffraction techniques gave a wealth of information on internal structure but were not strictly limited to surfaces. The diffraction of electrons came closer to the point. Gas adsorption techniques were developed which provided still more information about surfaces. The desirable goal, however, was not only to interpret the composition of the surface, but to see it and watch it in operation.

For this purpose optical microscopy is inadequate because its limited resolving ability is about 2000 times too large for studies of atomic composition. The development of the electron microscope was an improvement, yet its resolving power is poorer by a factor of ten than the desired goal. A notable advance was recently made by means of a new concept, the field emission microscope developed by Müller. (Ref. Nov.-Dec. '56 AFCA Jrnl., pp. 12-13). This remarkable instrument has a resolving power of the order of atomic dimensions, say 2-5 Angstrom units, and has made possible the visual and photographic studies of atomic arrangement and motion of atoms on surfaces. Photographs of tungsten atoms taken by Müller attest to the extreme sensitivity of this microscope.

A new technique for zone-refining of materials in which the crucible is eliminated is being explored by the Franklin Institute. Zone-refining can produce materials of highly controlled purity and this allows one to study the basic properties of materials as semiconductors for transistor applications. Ultrapure metals have been demonstrated to have some unusual properties—for instance, there is a remarkable improvement in low temperature ductility for iron. The method has value other than for purifying metals. It may be used for adding controlled amounts of impurities to a reactive metal assuring homogeneous distribution and for solidifying powder compacts without contaminating the compacts with crucible material.

Parratt has found that it is possible to produce sputtering by transmission. A metal foil is bombarded by positive ions on one side and metallic atoms from the foil are ejected on the other side. The interpretation placed upon this phenomenon is that it involves a momentum transfer process rather than an evaporative one. This phenomenon, it is believed, has not been observed before. The potential application might be in the analysis of solids.

Pond and Harrison have developed a new technique whereby it is possible to actually witness the submicroscopic upheavals occurring in a metal as a result of plastic deformation. Since the primary mode of plastic deformation in metals is by "slippage" of the metal along specific planes, precipices are formed on the surface by the deformation process. With this technique it is possible to observe the formation and movement of these precipices just as earth masses move during earthquakes. The extent of movement, however, is quite small, being a few hundred atom diameters.

Exploratory research in the sciences occassionally finds immediate application. A notable example is the excellent infrared indium antimonide cell, produced at the Chicago Midway Laboratory. As a by-product a second type of photodetector, the photoelectromagnetic cell, was also developed. These cells have already been constructed and distributed to interested laboratories. The stimula-

* High Temperature Research. An Important Chemical Frontier" —Report by Charles S. Stokes.—Ed.

tion provided by this exploratoy research has advanced practical applications by several years.

These accomplishments of Air Force-sponsored investigators in chemistry and solid state are striking examples of how research, through the clarification of scientific knowledge and exploration of new natural phenomena, opened up new frontiers and provided new approaches for materials. As implied in the opening paragraph, we require materials for structures, propulsion, control and guidance, and protective equipment. Designers of these devices are limited to the properties of known materials such as:

Compressibility
Density
Elasticity
Electromagnetic
Energy Content
Heat Conductivity
Plasticity
Reactivity
Strength

A major effort in requirements research, technical development and engineering is devoted to manipulation of various substances such as metals, alloys, ceramics, plastics, textiles, etc., into different combinations and testing of them for gross properties to meet requirements. Inchwise improvements often result, even though we do not understand the true detailed nature of matter. We have given names to the various building units of matter, such as:

Atoms
Molecules
Ions
Subatomic Particles
Crystals
Radiations
Energy

The chemists, physicists and solid state scientists, devoted to exploratory research, concern themselves primarily with the behavior of these building units in various states (gases, liquid and solids) and in various systems (colloidal, homogeneous or heterogenous).

Unlike requirements research, where the end item can be tested in use, the exploratory scientist must generally devise indirect approaches when measuring and predicting "fine" properties of these building units as he attempts to clarify existing knowledge or explore new phenomena.

Columbus, Livingston, Daniel Boone, Lewis and Clark, equipped with the tools and techniques of their day, charted oceans and the interiors of continents to satisfy their own curiosity. Just as civilization and stabilized states followed their charts and pathways, so do most of us who are trained in science and engineering follow in the pathways of the scientific frontiersman. Most of us can tackle the requirements-type of research with a great deal of ingenuity. It is this capability which has enabled us to live in and enjoy an age of unprecedented material advantages.

To remove existing limitations intrinsic in the material sciences, it is important that we encourage our scientific frontiersmen to open up new areas. Since funds are limited, we are faced with the problems of administrative selection: How, for example, do we evaluate and select proposed exploration? We ask ourselves: Is it an exploratory investigation or is it a requirements' problem? Is the idea imaginative and novel, yet scientifically reasonable? If he attains his scientific objective, will his accomplishments be significant? Does his institution have the facilities and provide the environment to enable the investigator to carry out his idea? Is the cost reasonable? And finally, does the investigator, as judged by those who know him, have the initiative and capabilities to carry out the proposed exploration?

No one can predict which exploration will provide important breakthroughs any more than the wildcat oil driller can predict that he will bring in a new gusher. But the pay-off is indeed high for both when successful. There are those who insist that we must program or predict which ideas will pay off before research is done. They fail to see that research efforts can never assure the achievement of specific new technical performance, nor can the effort necessary to accomplish any considerable definitive technological advance be accurately estimated.

Who could have programmed the independent discovery of paramagnetic resonance by Percell and Bloch—the one new technique since 1945 which has received more widespread application than any other? In recognition, they jointly received the Nobel Prize. The most convincing demonstration of the versatility of the method is a brief table of some problems in which some important answers and information have been obtained. Chemists, chemical engineers, physicists, physiologists, geologists, botanists and physicians are actively utilizing this method in their own research.

TABLE

Application of Nuclear Resonance

1. Rapid analysis of moisture content.
2. Decision of structure among alternatives where other methods leave ambiguities.
3. Alignment of nuclei for atomic fission experiments.
4. Non-destructive and rapid analysis of components in gasoline or diesel oil.
5. Continuous monitoring of chemical processes.
6. Measurement of flow rates without insertion of a meter in the stream.
7. Amplifier design for use at extremely low temperatures.
8. Assessment of the nature of internal motions in solids.

Some Applications of Electron Magnetic Resonance

1. Measurement of small changes in the earth's magnetic field as in geophysical prospecting.
2. Follow up of chemical reactions occurring in photosynthesis when chlorophyll is exposed to light.
3. Assessment of the nature of radiation damage in solids and of the decay of active fragments.
4. Investigation of conduction electrons in metals.
5. Studies in the formation of polymers (plastics) and their internal rigidity.
6. Investigation of the reactions of antioxidants, i.e., substances which may be used to prevent deterioration of rubber.
7. Study of irradiation of compounds which help to diminish radiation damage in animals.
8. Investigations of the behavior of impurities in silicon or germanium used in transistors.

In order to advance beyond the materials barricade, the Air Force Office of Scientific Research actively assists those men of science whose ideas for exploration of new areas are original and imaginative. Here success, while elusive, will provide the greatest pay-off to the Air Force.

MORE AIRPOWER FOR SURVIVAL

By Olin H. Borum

*Lt. Col. U.S. Air Force Reserve**

(This article was prepared while the author was attending the 1955-56 course at the Air Command and Staff School, Maxwell Air Force Base, Ala. Holder of a Ph.D. degree in chemistry, he is now employed in a civilian capacity by the Army Chemical Corps. See note below.—Ed.)

A factor that delays the development of our air power is the inadequacy of present structural materials. An example of the result of this is the so-called "thermal barrier" which causes failure of structural materials because of the frictional heating by the atmosphere of planes and missiles traveling at speeds greater than the speed of sound. Elimination of these material deficiencies is slowed by a lack of basic knowledge concerning the properties of materials. It will be largely up to the chemical sciences to provide this knowledge so vital to our air power.

Air Force Manual 1-2, dated 1 April 1955, and entitled *United States Air Force Basic Doctrine,* describes just what the airman means by air power. "Active military forces, reserve air forces and their supporting facilities comprise a major component of air power. Total air power also includes the entire civil aviation enterprise; the whole system of research, development, and production; and the trained personnel, military and civilian, in both an active and reserve capacity." It will be some of the research and development aspects of air power that I shall consider.

The importance of scientific research and development to air power is emphasized by Brig. Gen. Dale O. Smith, who was formerly assigned to the Operations Coordinating Board in Washington. In his book, *U.S. Military Doctrine,* he states, "It can be said with assurance that modern civilization has forced us to recognize a tenth principle of war, which is this: 'Technological change has a significant influence on the art of war, and the military power which first learns how to exploit new devices will have a greater chance for success in war.' " By this statement General Smith ranks technology along with the nine standard military principles of war.

There are many fields of science and engineering that advance the operational capability of the U.S. Air Force. One of these is chemistry. Chemistry is a science that deals with material substances and we would expect that a solution to problems in materials would be aided by chemistry. Some of these problems are discussed below.

Fuels. Suitable fuel is a problem for today's plane. As the range of our aircraft is increased our air forces achieve greater operational flexibility and we thus have more air power. This increase in range requires more fuel and more efficiency in its use, and poses a problem in fuel economy. We shall be dependent upon jet hydrocarbon fuels until our scientists provide nuclear propulsion or high-energy chemical fuels for planes. At high speeds, even at high altitudes aircraft generate high skin temperatures. For example, at Mach 2 at 35,000 ft. a temperature of 235° F. is generated. Under these conditions jet fuels tend to volatilize away. Also, in the rapid climb from the ground fuel losses occur from heating and from reduced pressures. When the Air Force changed from JP-1 (kerosene) to JP-3 fuel (a mixture of 70% gasoline and 30% light distillate) during the Korean conflict losses of fuel were as high as 90% in some cases. This was solved by the removal of dissolved butane and pentane gases. This caused lower vapor pressure. Development of JP-4 reduced excessive fuel losses at high altitudes. It is composed of some gasoline and light distillate fractions.

Volatility was not the only fuel problem, however. Others concerned availability, thermal stability and stability in storage. Kerosene, or JP-1, was the first jet fuel, and it constituted only about 6% of the crude petroleum. Work on this problem gave approximately one-half of the crude as available jet fuel. Development of the process of fuel hydrogenation gave a fuel of good thermal stability. In this chemical process hydrocarbon molecules are altered under a hydrogen pressure of about 500 pounds per square inch. Chemical additives have also been developed to dissolve sludge or prevent its formation and to improve stability in storage.

Combustion Research. Flame-outs present a problem, especially for high speed planes flying at high altitudes. It is inadvisable to attempt re-ignition at altitudes above 25,000 ft. because of the danger of detonation instead of re-ignition. We do not adequately understand the phenomena involved. Basic research is needed to provide information that can be used as a tool to solve such problems. An approach to this problem has been the application of chemical kinetics.

A jet fuel is desired that burns steadily without oscillations of the flame front which either cause flame-out or permit explosive unburned gases. Problems of com-

* Olin H. Borum, 39, is now employed as Physical Science Administrator, Research & Development Command, Chemical Corps, U.S. Army, with office in Washington, D.C. He has a B.S., an M.S., and a Ph.D. degree in chemistry from the University of North Carolina. Dr. Borum has worked in industry as an analytical and also as research chemist and has taught chemistry at the University of Maryland and the U.S. Military Academy, West Point, N.Y. He entered on active military duty as a 2nd Lieutenant with the Chemical Warfare Service of the Army in 1941, served at Edgewood Arsenal, later as a chemical officer with Army Air Force in the Caribbean and Antilles areas, and after that with the Seventh Army in Europe. Commissioned in the Air Force after the War, he served on active duty during the period 1951-1956 including three years as instructor and assistant professor of chemistry at West Point.

bustion have been fairly well solved for reciprocating engines, but this is not true for jet and rocket engines. Combustion problems concern matters such as the initiation and propagation of flames, reaction mechanisms, the use of fuel oxidants and the development of better fuels. These problems are being studied.

Propellants. Chemical studies are being made on the instability of rocket fuels. Unlike air-breathing jets, rockets need an oxidant as well as a fuel. The oxidant and fuel are together referred to as the propellant. Some commonly used combinations are gasoline and nitric acid, alcohol and liquid oxygen, and alcohol and hydrogen peroxide. These liquids are termed bi-propellants, as prior to inter-action they are kept separate. Research on bi-propellants determines the time required for complete reaction of oxidant and fuel. Because of these studies this time has been reduced which permits a reduction in the required volume of the combustion chamber with consequent reduction in size, weight, cost and cooling requirements. The results of research on propellants might well determine the efficiency and timely development of our ICBM missile as compared with that of the Russians.

Chemists are also developing solid-type fuels. Studies are being made to determine their burning rates, ignition qualities, specific impulse values and the need for fuel binders. Elastomers can function as such binders.

The economy of various propellants is important in selecting them for Air Force use. JATO fuels to assist conventional planes during take-off are used in large quantities. Therefore, readily available fuels of low cost are desired, even if they are not the most efficient ones available. Long distance rockets are expensive and are, of course, expended in use. The cost of the fuel is a small part of the total cost of the rocket. Since the accuracy and reliability of these rockets are of prime importance it is necessary to use the propellant with the highest specific impulse (pounds of thrust per pound of fuel), regardless of the cost, as long as the cost is still small as compared with the cost of the rocket itself. Although definite progress has been made there is still much work to be done in developing optimum propellants for Air Force use.

Lubricants. The high speeds and altitudes associated with jet plane operations have created problems in lubricants that have been partially solved and are currently being investigated.

No pressing problems exist with respect to engine oils for reciprocating engines. However, jet engines need a different type of oil. Indications are that future jet engine oils must operate at temperature extremes of about —67°F. and 800° F. The lower value represents atmospheric temperatures at higher altitudes of operation as well as some ground Arctic temperatures. Current investigations focus attention on non-hydrocarbon types such as silicon and phosphorous organics and fluoro compounds. For the hydrocarbon types chemical additives improve performance. Tricresyl phosphate may be added for wear protection, amines and phenols added as antioxidants, and sulfonates as rust inhibitors. Investigations have shown that aliphatic sulfonates added to petroleum base lubricants inhibit corrosion and these have been added. However, when added to such a synthetic lubricant as di-(2-ethyl-hexyl)sebacate corrosion is increased. Research is underway to study the mechanism of this action and to learn why this occurs.

Adequate lubricating grease is also required. The control bearings and actuators (fractional horsepower motors) in the vicinity of the tail pipe of jet aircraft may reach temperatures above 600° F. The standard high temperature grease is a mixture of about 18-24% soap with a petroleum base. The best available greases may last 150 hours at 350° F. Synthetic greases that are expected to operate up to about 500° F. are being investigated as are solid lubricants such as molybdenum disulfide for temperatures exceeding 500° F. The lower temperature limit of —67° also imposes special problems. A grease composed of lithium stearate and a diester has been formulated that works down to about —65° F. Other formulations are under investigation to function at temperatures near —100°F.

The mechanism of grease flow and lubrication is not thoroughly understood and is being investigated. Other agents that produce gelation of hydrocarbons are under study to take the place of soap.

With the advent of guided missiles that use nitric acid and other strong oxidizing agents, requirements will exist for lubricants to withstand their action.

Hydraulic Fluids. Present problems of hydraulic fluids are those of inflammability and instability at high temperatures. Current investigations are directed toward providing nonflammable fluids of high thermal stability. Silicate base fluids have been developed toward this end.

Textiles. In the field of textiles the chemist has contributed such fibers as nylon, used extensively to make personnel and cargo parachutes, drag chutes and tow lines. It does not take much imagination to see how our air power has been increased by using drag chutes which enable the use of existing shorter runways. More recently, dacron has been introduced. Nylon loses much of its strength above 350° F. whereas dacron can be treated to retain its strength at temperatures as high as 400° F. for extended periods of time.

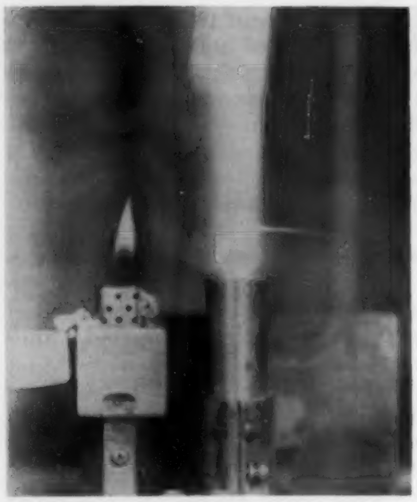
Adhesives. The application of special adhesives to metals has resulted in bonding that in many instances has eliminated the need for rivets. This has resulted in weight saving and reduction in metal fatigue problems. Fatigue has occurred at rivet holes and has caused plane failures. The weight saved on some jet air-liners has been said to approximate the weight of the payload of passengers and freight. Adhesives have been used in helicopter blade construction and have largely eliminated failures formerly occurring at spot welds where the blade spar and collars were attached. Epoxide-phenolic copolymers function as adhesives and have shown excellent properties at 500°F.

Plastics. An ever present search is underway for improved plastics for such components as radomes, canopies, windows and insulators. With the acrylate plastics heat distortion begins to appear at about 190° F. (Remember that at Mach 2 and 35,000 ft. aerodynamic friction produces a skin temperature of around 200° F. At ground level this would be 300° F. Also skin temperature is always less than 90% of ram air temperature). Plastics are desired that maintain their strength at much higher temperatures.

Another plastics problem is that of "crazing" or interference with transparency. It may be due to the laminated structure of the plastic. Fundamental research on the bonding of interlayers and the mechanism of transparency is underway.

Reinforced plastics have replaced metals in many uses. For example, the Zenith Plastics Co. has developed a plastic structure that is used by Lockheed for the entire stinger tail of the P2V. It has about ⅔ of the weight it would have if made from the lightest practicable metal, and Zenith estimates that it can be produced with about 1/7 the floor-space, 1/6 the production manpower and 27% of the equipment and tool costs for an equivalent metal structure. Basically, it is of sandwich type con-

(Continued on page 37)



Boiling Iron with the Cyanogen-oxygen Flame—The premixed oxy-cyanogen flame develops a temperature of 4830°K. (8270°F.). Several strands of iron wire are being fed into the flame. The vapors produced burn in the outside air in the form of streamers, producing a sparkler effect. The temperature of the cigarette lighter flame is approximately 3250°F.

HIGH TEMPERATURE RESEARCH

Reported by

Charles S. Stokes

Research Associate

The Research Institute of Temple University

Philadelphia 44, Pennsylvania

March 29, 1957

High temperature chemistry, still one of the least understood areas of chemistry, is one of major importance both to fundamental science and to the missile and aircraft industry. The Research Institute has been interested in the field since A. V. Grosse, its president, joined the organization in 1948. At that time the hottest known flame (3400°K., 3130°C.) was produced by the oxyacetylene torch.

Members of the present group conducting this research include: William L. Doyle, A. D. Kirshenbaum, W. J. Liddell, Alex G. Streng, Robert Werner, and J. B. Conway (now at GE). They have already passed 5300° Kelvin.

The purpose of the Temple program is twofold:

To obtain, maintain, and contain high temperatures.

To study the chemical and physical phenomena taking place at these temperatures.

High temperatures can be reached by other than chemical means. An electric arc, for example, can be very hot, but the heat effect is limited to the relatively small area of the arc itself. High temperatures, at least to 3300°K., can also be produced in a small area by focusing the sun's radiation. This works well for heating small amounts of solids or liquids, but most gases, being transparent, will not absorb heat from the sun's rays.

Explosive nuclear reactions, such as of an atomic bomb, produce a great amount of heat, too, but it is uncontrolled and lasts only for an instant. In atomic reactors, temperatures normally do not get above 800°K.

To produce high temperatures, a chemical reaction must be highly exothermic and its products of combustion must be thermodynamically stable at the temperatures produced.

The hydrogen-oxygen flame—until recently one of the hottest— cannot exceed 3000°K.; above this temperature water, the combustion product, dissociates back to hydrogen and oxygen. Use of fluorine, which is more electronegative than oxygen, gives more stable combustion products, so that temperatures up to 4300°K. can be produced.

The hydrogen-fluorine flame has a burning velocity far in excess of any other known flame; by premixing the two gases, a flame of 10 times the burning velocity of hydrogen-oxygen mixtures, fastest burning mixture known previously, can be obtained. Because the gases tend to be self-igniting this is a rather hazardous operation, requiring that they be very pure, precooled, and mixed in glass apparatus. A mixture containing 20% fluorine burns at a velocity of 2200 centimeters per second; flame velocity of city gas with air, on the other hand, is about 30 centimeters per second.

Because dissociation of combustion products is hindered, higher temperatures result from increasing pressure—as is usual in rocket operation. The hydrogen-fluorine flame, for instance, can be upped to 4800°K. under pressure. Likewise, a flame of hydrogen cyanide and an equimolar mixture of fluorine and oxygen can produce a temperature of 4000°K. at 1 atm. This high temperature flame is produced from commercially available materials and it too may be raised to 4800°K. range by increasing the pressure surrounding the flame.

Even hotter is the cyanogen-oxygen flame, which until recently produced the hottest flame that could be obtained by a chemical reaction (at 1 atmosphere over 4800°K., at 10 atmospheres nearly 5100°K.). The products of cyanogen combustion, nitrogen and carbon monoxide, are among the 10 molecules stable enough to exist at temperatures of the sun.

But end product stability is not the only factor. The high temperature of the cyanogen flame results also from the thermodynamic instability of cyanogen itself, which decomposes with the liberation of heat:

$$N \equiv C - C \equiv N \rightarrow C_2 + N_2 + 74\ \text{Kcal.}$$

Substituting the endothermic oxides of nitrogen for oxygen in the oxy-cyanogen flame gives the following results.

Oxide	*Flame temperature ° Kelvin*
O_2	4830
N_2O	4195
NO	4865
N_2O_4(gas)	4625

It will be noted that nitric oxide and oxygen produce about the same flame temperature with cyanogen. This is due to the relatively high positive heat of formation of nitric oxide (+21.6 Kcal.).

A compound more exothermic than cyanogen—and having the same combustion products—should produce

[1] This research was supported by the United States Air Force through the Air Force Office of Scientific Research of the Air Research and Development Command under Contract No. AF 18(600)-1475.

[2] Part of this paper is a revision of an article appearing in *Chem. & Eng. News*, 34, 3442-3445, July 16, 1956, and is reproduced by permission of the American Chemical Society.

still higher temperatures. The dinitriles of acetylene-dicarboxylic and polyacetylene-dicarboxylic acids or dicyanoacetylene and dicyano-polyacetylenes fit this description. Their structural formula is:

$$N \equiv C - (C \equiv C)_n - C \equiv N$$

The first member of the series, carbon subnitride (C_4N_2), when burned with oxygen, produces a temperature of 5300°K. at 1 atmosphere and should produce 5750°K. at 41 atmospheres.

Ozone, another unstable substance, liberates 34 Kcal. per mole on dissociation into oxygen. Thus, substitution of ozone for oxygen substantially increases the heat produced in most combustion reactions. With carbon subnitride, ozone should produce 5500°K. at 1 atmosphere; this is the next objective of our program.

Subsequent members of the series have not been described in the literature, but the dicarboxylic acids, from which they are derived, are known. These may provide the way to still higher temperatures.

Considerable effort has been placed upon the use of ozone as an oxidant. Ozone has been successively burned as a free flame to oxygen:—

$$O_3 \rightarrow 1.5O_2 + 33.9 \text{ Kcal.}$$

This unimolecular decomposition reaches a temperature of 2692°K. and a burning velocity of 475 cm/sec. at 300°K. and 1.0 atm. for 100% ozone.

Recent investigations show that ozone can be mixed without detonation with various fuel gases such as hydrogen, methane, cyanogen, etc. Thus premixed flames of these fuel gases using ozone as the oxidizer can be realized.

High temperature chemistry has just come of age. It has been a badly neglected field of science for the past decade and is an area where much work must be done in order to keep up with the ever increasing complexities of the missile and aircraft propulsion plants.

—U. S. Army Photo

This "one-shot" portable flamethrower, now under development by the Army Chemical Corps, was displayed in a recent Army exhibit in New York. Holding it is M/Sgt John Ryea, one of the Chemical Corps specialists who was on hand to discuss the various display items. The portable multi-shot flamethrower now carried by American soldiers weighs 72 pounds when fully loaded with fuel; the new "one-shot" weighs about 26½. It is designed to be expendable but can be recharged and used again.

CBR STRENGTH

(Continued from page 16)

not considered lethal. Others cause more serious physiological symptoms, such as respiratory disturbances, blistering of the flesh, disruption of the blood, or the nervous systems of the body. These latter types can be lethal if the victim does not receive immediate first aid or medical treatment, and recovery may take weeks or months.

Biological Warfare is the use of disease to affect men, food, animals, and crop plants. Like the chemical agent, those of the biological variety can be either mere nuisance diseases or more serious illnesses from which the victim may, or may not, recover. We have a nature-made biological warfare situation around us all of the time. But, while there are thousands of diseases in this world, only between five and ten percent are harmful to man. Only a small number of these germs are hardy enough to withstand the rigors of artificial dissemination.

Radiological Warfare involves the idea of intentionally scattering radioactive material—such as dust, for instance—on a specific target area. The effects would be the same as those occurring from the natural "fall-out" cloud of a nuclear detonation. And, like chemical and biological warfare, the effect could vary from temporary illness to death, depending upon the amount of radiation to which a victim were subjected.

Now let us examine the advantages of these systems that might lead an aggressor to select them, a possibility we must recognize and for which we must be prepared. These toxicological agents of war have much in common; they cannot ordinarily be detected by the human sensory organs; they can circumvent—or in the case of radioactivity, penetrate—normal means of protection against the more common explosive type munitions. They are flexible in that the user can control the effects upon the victims through the choice of an agent which may merely incapacitate, or which may kill. While other forms of warfare cause casualties by painful blows or wounds, the toxicological agents can often perform their debilitating action without the victim being aware of it. They cause no destruction of buildings or machines. While a rifle bullet or a high explosive munition loses its effectiveness within seconds after being set in action, the toxicological munitions may pose a health problem for varying periods of time ranging from minutes to days. Normally, they are released in an heavier-than-air aerosol form which flows over the ground like water, seeking the low places. The chemical and biological agents are—at least theoretically—relatively easy to defend against—the basic means of protection is a supply of clean, uncontaminated air which can be obtained individually through the protective mask, or through mechanical filter devices for use in shelters and buildings.

It is the responsibility of the Army Chemical Corps to provide our nation with much of the means of coping with toxicological warfare. As the only agency of its kind in our government, the Corps must carry out the research and development, the procurement or manufacturing, the storage and supply, and certain phases of training to provide this defensive capability not only among the agencies of the Department of Defense, but also others such as the Federal Civil Defense Administration and the U. S. Public Health Service.

Materiel-wise, today we have reason to believe that we hold a technological superiority in the means of defending ourselves against the CBR weapons. But, mentally, we are not so well prepared. It is not generally recognized that these are weapons-in-being and that they are just as likely to be used against us as the nuclear weapons.

There still exist some gaps in our thinking regarding the realities that face us.

Today, we are devoting much time and effort to prepare for the possibility of nuclear warfare and to perfect our defenses against it. But, in building such strength we must not overlook another potential hazard—that of CBR Warfare. It would not do us much good to survive an atomic attack only to fall victim to a subsequent toxicological attack.

There is an old military maxim that has proved useful to military commanders down through the ages—"hit the enemy at his weakest point".

An unfriendly nation studying our ability to defend ourselves and the rest of the Free World will be well aware of our strength in the nuclear field and will govern his plans accordingly. He also must be made aware of our ability to defend ourselves in the toxicological field lest he be tempted to resort to the use of these munitions. And, needless to say, we must have such an ability.

We know that other nations are thinking in terms of gas and disease germs as a means of war. For instance, just a year ago at the Communist Party Congress in Moscow, Soviet Defense Minister pointed out that ". . . . any future war will be characterized by the mass use of airpower, various types of rocket . . . atomic, thermonuclear, chemical, and biological weapons. . . .". The warning is there for all of us to see.

One of the things that has worked to our detriment in building our defenses against the CBR weapons is the air of mystery that has been created around them in the public's mind. Actually, though, there is no mystery about them, for we have forms of chemical, biological, and radiological warfare all around us in our daily lives.

For instance, the housewife who cooks with a gas stove has a lethal agent at her command. The unthinking person who uses carbon tetrachloride to clean clothes in a closed room is subjecting himself to much the same dangers as those which would be encountered under gas warfare conditions. The man who drives his car with all the windows shut tight, is exposing himself to the lethality of carbon monoxide gas. Many industrial workers face a constant health hazard from chemical fumes in their plants, and some of our cities are subjected to dangerous smog attacks—not unlike the aerosol cloud of a war gas.

Regarding Biological Warfare, we are constantly fighting Mother Nature to maintain our health, and we have radioactivity all around us in the form of cosmic rays, x-ray photos of parts of our bodies, and radium dials of our watches.

We do not worry unduly about these things, we accept them as normal hazards of civilization. We have come to understand their potentialities, and we take the necessary steps to nullify the possibility of harmful effects. Familiarity doesn't breed contempt for these hazards, it breeds a form of respect. So it is with the CBR weapons, we must breed a form of respect for them as potential hazards to our way of life. And, when this has been done and we have engineered our defenses against them to the same standard as that attained in the nuclear weapons field, we will have closed a possible gap in our security system. We will have created one more area in which an enemy could hope for little profit from an attack, and so helped to deter his aggressive instincts a bit longer. However, let me make it clear,

when we speak of "defense" we are including the ability to use such weapons in retaliation if necessary. For as Stalin once said, "in scientific warfare, he who prepares only for the defensive in digging his own grave".

We of the Chemical Corps do not say that the toxicological munitions would cause us to lose a war by themselves. They won't. But, it is very possible that used in conjunction with the other weapons they could be the force that swings the balance.

We are continually asked, though, "Why should an enemy consider CBR Warfare when the nuclear bombs will do the job so much quicker?"

The answer is simple. The use of atomic or nuclear munitions are weapons of total destruction.

Military attacks are not necessarily undertaken to destroy, but to occupy territorial space for which the occupier foresees a use. This is true whether it is a squad-size attack to obtain a high spot of ground which can be used as an observation post, or an international attack to subdue an entire nation.

World War II was the most costly and destructive conflict in history. More than 52 million people were killed or injured—more than half of them civilians. The belligerent nations spent more than a trillion dollars on armaments and war materials. The other material costs were immeasurable. And, the world has seen what a costly business it has been to re-build the destroyed nations to the point where they are economically self-sufficient and much less a burden on the rest of the world's economy.

None of us can say this will not happen all over again. On the other hand, we can also see the object lesson in what happened. And, when we do, we can see why the toxicological weapons may appeal to an aggressor.

For instance, the removal of industrial machinery from Germany and Manchuria at the end of World War II show how highly prized are productive facilities by the Soviet. We might ask ourselves if our productive facilities might not be equally prized. The use of nuclear weapons on an indiscriminate basis could destroy our productive facilities and leave them useless for post-war use. And, of course, any aggressor would be thinking only in terms of victory. To be of use to him, our steel mills, machinery producing plants, and the many other factories that an enemy could use for his own benefit, would have to be intact at the end of hostilities.

To achieve this, he could use toxicological munitions which would attack only the human personnel so necessary to run the machines. By causing death, or merely debilitating illnesses among them, these workers would lose their productive efficiency. And with this decrease in industrial production, our Armed Forces would soon become seriously weakened through the lack of munitions, equipment, food and medical supplies.

There is also the thought that the enemy would see the need for slave labor to run the factories he has left intact. A nuclear munition would kill or maim these people and they would be of little use in the post-war economy. But, through the use of specific biological agents, the enemy could make these people so ill that they could not work for long periods of time during the period of combat—but would be available as a manpower supply later on. Or, through the use of livestock or plant crop-killing diseases, he could weaken the population through lack of food. I have used biological agents as illustration for this point since they are ideally suited for strategical use by an aggressor where the element of time is not so important as on the battlefield. They are also most suitable for enemy sabotage work which could be carried on long before an open attack, or even a declaration of war. However, the hazard of gas warfare would be just as great.

While these thoughts are in a humane trend when we think in terms of being potential victims, they also have a military justification. Studies made after World War I showed that a man wounded by gas had a 12 times better chance of survival, unmaimed, than did a man hit by flying lead or steel. An aggressor might well consider that this makes for a drain upon manpower reserves since a wounded person needs five or six other people to care for him during the convalescent period, while a dead person is no such liability. The same holds true for biological warfare agents, for a potential enemy might consider many diseases which can debilitate a victim for long periods of time without causing death.

No toxicological munitions were used in World War II. This was because our announced national policy was that we would use toxics only as a means of retaliation for like attacks upon us, or our Allies. The Axis nations were well prepared to use gas, and so were the Allies. However, Hitler and Tojo realized that they could not match us on a production basis, and so hesitated to initiate gas warfare. However, there is evidence that Hitler, in a final, last-ditch stand, was willing to take a chance and order the use of gas on our troops.

As we think of our defensive needs in the CBR Warfare field, we have only to make a 180 degree turn in our thinking to see why an enemy might fear our retaliatory capability. This fear must be such that an aggressor will even refrain from its use in the peripheral-type wars—such as Mussolini did in 1935, when he attacked the Ethiopians with a small force of troops and large amounts of mustard gas.

What then, must be done if CBR Warfare strength is to aid in deterring war?

First, we must bring about a general realization that the toxicological munitions pose a hazard to our national welfare along with those of the nuclear weapons and that we must be strong in our ability to protect against them.

Second, we must strip the air of mystery from the toxicological munitions so there will be a greater understanding of their nature.

Third, we must incorporate the mechanical means of defense the Corps has perfected for military use against the toxic weapons into our civil defense planning.

Fourth, we must continue to exploit the great strides being made in chemical and biological research by industry and adapt these advances to defense use wherever possible.

Fifth, we must be so strong in the CBR Warfare field that an aggressor would see no "profit" in its use and so be deterred from any temptations to use these weapons.

The day when we can realistically say that our civil defense planning against toxicological attack is on a par with our atomic defense system—when we can say that our means of total defense is on a par with the enemy's potential of offense—that will be the day when we will have achieved a CBR strength that can serve as a useful "tool" in engineering total peace. For it will have removed one more area in which the enemy could make a "profitable" attack.

1958 ANNUAL MEETING IN JUNE TO BE HELD IN ATLANTIC CITY

Plans are now firm for holding the 13th Annual Meeting of the Association on June 5 and 6, 1958, in Atlantic City, N.J., with accommodations at the Traymore Hotel.

The announcement was made at a recent meeting of the Executive Committee by Colonel Harry Kuhn, past president, and member of the special committee, with Brig. General Clifford L. Sayre, chairman, appointed to make these arrangements.

TALKS ON PSYCHOLOGY TO BALTIMORE CHAPTER

EDGEWOOD, MD., Mar. 5—Dr. Leonard S. Rubin, chief of the psychology and human engineering branch of the Chemical Warfare Laboratories here, spoke to a gathering of over 75 members of the Baltimore chapter, Armed Forces Chemical Association, at the Gunpowder Officers Mess on the subject of "Application of Psychology in Industry."

The group, consisting of top representatives of several Baltimore industries and military leaders, was given an insight on how psychology in industry affects job assignment, production, and morale.

The special committee appointed to study plans for a merger between the Baltimore and Army Chemical Center chapters has reported that most members polled are in favor of the merger and it is expected this will be accomplished about July 1.

PINE BLUFF CHAPTER ELECTS NEW OFFICERS

Col. L. C. Miller is the newly elected president of the Pine Bluff (Arsenal) Chapter, Pine Bluff, Ark. This Chapter was reorganized at a meeting on 22 March, 1957, when the following officers, besides Colonel Miller, were elected: Capt. R. F. Nastre, 1st Vice-President; Mr. R. B. Spencer, 2d Vice-President; Mr. T. H .Foster, Secretary-Treasurer. For the Board of Directors: Col. R. W. Dodds; Mr. J. M. Howard; Maj. W. E. Sexton; Maj. C. B. Dykes, and Mr. O. D. Stone were selected.

DIAMOND SYSTEMATIZES STUDENT RECRUITING

A booklet of instructions to company personnel on how successfuly to interview and recruit prospective college graduates for technical positions in the employ of Diamond Alkali Co. has recently been prepared by the Company's Personnel Division.

By means of check lists for guidance of recruiters, the booklet covers the recruiting field from advance preparation of the recruiter to the interview of the student and followup visit.

Mr. Arthur P. Schulze, Advertising and Public Relations Manager of the Company, states that the Company would be glad to furnish copies of the booklet to A.F.C.A. members who might be interested in having it.

FRANK DOUGHERTY OF FERRO HEADS CLEVELAND CHAPTER

The following new officers of Cleveland Chapter were elected at the annual meeting March 29, 1957: President, Mr. Frank Dougherty, Ferro Corp.; 1st Vice-President, Mr. C. H. Alexander, B. F. Goodrich Chemical Co.; 2nd Vice-President, Mr. G. C. Whitaker, Harshaw Chemical Co.; Secretary-Treasurer, Mr. W. V. Tracy, Monarch Aluminum Co. For the Board of Directors, Mr. Ralph Keller, Industrial Service Co.; Mr. Bruce Colwell, Adache Engineers, and Mr. David Benjamin, Benjamin Reel Products Co. were named.

MIDWEST MEETING PLANS

According to "The Detonator," Midwest Chapter's monthly publication, the chapter is considering plans for a cruise on Lake Michigan for its annual meeting in May. An idea being discussed is a father-son affair with a visit to the U.S. Navy's Great Lakes Training Station.

PINE BLUFF SECRETARY HONORED

Mr. J. Milton Howard, Secretary-Treasurer of Pine Bluf Arsenal (Arkansas) Chapter, was recently awarded the A.F.C.A. plaque for his outstanding efforts on behalf of the Association, including the signing of 10 new members.

In the picture above Mr. Howard is receiving congratulations from Major Claude B. Dykes of Midwest Chemical Depot.

DR. R. L. FOX RECEIVES PLAQUE

EDGEWOOD, MD.—Mr. W. H. Sheltmire (right), Baltimore chapter, A.F.C.A. vice president for membership (Olin Mathieson), presents the A.F.C.A. plaque to Dr. Robert L. Fox of the Chemical Warfare Laboratories in recognition of his outstanding job in signing fourteen new members to the association during its recent membership drive.

NERVE GAS FILM

A 30-Minute Color film, graphically describing how an aggressor might deal swift death to thousands by using nerve gas was given a premiere showing in the Mayflower hotel in Washington, D.C., March 1.

The film, entitled "Nerve Gas Casualties and Their Treatment," portrays the effects of nerve gas and the treatment of casualties. It is sponsored by E. R. Squibb & Sons, a division of Olin Mathieson Chemical Corp., and was produced with the cooperation of the Federal Civil Defense Administration.

Advisers on the project in addition to FCDA included the Office of the Secretary of Defense, the Chief Chemical Officer of the Army, the Army Surgeon General, the U.S. Public Health Service and the American National Red Cross.

Members of Congress, officials of interested Federal agencies, and representatives of the press attended the premiere.

The film portrays the effects of nerve gas on both animals and people, using an animated chart to show how the gas acts on the human nervous system. Nerve gases may be absorbed anywhere on the body's surface—especially through the nose and throat, and in liquid form through the skin.

FCDA officials explained that nerve gas was developed by Germany during World War II.

Three basic first aid measures to counteract the effects of nerve gas are advocated and shown in the film, which is designed especially for training of civil defense personnel. These are:

1. Protect from exposure by wearing suitable masks.
2. Inject atropine into the body muscles. Atropine is widely used to relieve muscular spasms. Up to three two-milligram doses may be given at 5-to-10-minute intervals without medical supervision. It may be self-administered, using a specially designed Syrette for the purpose.
3. Use artificial respiration—the back-pressure, arm-lift—as taught in the American Red Cross' and Bureau of Mines' standard first-aid courses.

PITTSBURGH ANNUAL MEETING

Pittsburgh Chapter of A.F.C.A. held its annual meeting and dinner at the University Club, Pittsburgh, Pa., on the night of March 29, 1957. Guest of Honor was Mr. Glenn Hutt, National President of A.F.C.A., and the banquet speaker was Mr. Harry N. Cotabish, Research Engineer, Mine Safety Appliances Co. His subject was "A Project Engineer's concept of conducting research and development for the Chemical Corps."

GROUP AND SUSTAINING MEMBERS

OF THE ARMED FORCES CHEMICAL ASSOCIATION

Abbott Laboratories, North Chicago, Ill.
Adache Engineers, Cleveland, Ohio
Air Reduction Company, Inc., New York, N.Y.
Allied Chemical & Dye Corporation, New York, N.Y.
American Cyanamid Company, New York, N.Y.
American Zinc, Lead & Smelting Co., St. Louis, Mo.
Armour & Company, Chicago, Ill.
Armstrong Cork Company, Lancaster, Pa.
Astra Pharmaceutical Products, Inc., Worcester 6, Mass.
Atlas Powder Company, Wilmington, Del.
Baker & Company, Inc., Newark, N.J.
Baker, J. T., Chemical Company, Phillipsburg, N.J.
Barnebey-Cheney Company, Columbus, Ohio
Bechtel Corporation, San Francisco, Calif.
Becton, Dickinson and Company, Rutherford, N.J.
Bell & Gossett Company, Morton Grove, Ill.
Blaw-Knox Company, Pittsburgh, Pa.
Blickman, S., Inc., Weehawken, N.J.
Borden Company, The, Philadelphia, Pa.
Bridgeport Brass Company, Bridgeport, Conn.
Brown Company, Berlin, N.H.
Burroughs Wellcome & Co. (U.S.A.) Inc., Tuckahoe, N.Y.
Casco Products Corporation, Bridgeport, Conn.
Celanese Corporation of America, New York, N.Y.
Central Foundry Company, The, Newark, N.J.
Chamberlain Corporation, Waterloo, Iowa
City Chemical Corp., New York, N.Y.
Columbia-Southern Chemical Corp., Pittsburgh, Pa.
Commercial Solvent Corporation, New York 16, N.Y.
Continental Can Co., Inc., Chicago, Ill.
Continental Oil Co., Ponca City, Okla.
Crane Co., Chicago, Ill.
Diamond Alkali Company, Cleveland, Ohio
Dow Chemical Company, Midland, Mich.
E. I. duPont de Nemours & Co., Inc., Wilmington, Del.
Edo Corporation, College Point, N.Y.
Eldon Manufacturing Company, Los Angeles, Calif.
Empire Stove Company, Belleville, Ill.
Esso Research and Engineering Co., New York, N.Y.
Evans Research & Development Corp., New York, N.Y.
Federal Laboratories, Inc., Saltsburg, Pa.
Ferguson, H. K., Company, The, Cleveland, Ohio
Ferro Corporation, Cleveland, Ohio
Firestone Industrial Products Co., Fall River, Mass.
Fisher Price Toys, Inc., East Aurora, N.Y.
Fisher Scientific Co., New York, N.Y.
Food Machinery & Chemical Corporation, New York, N.Y.
Foster Wheeler Corporation, New York, N.Y.
Fraser & Johnston Co., San Francisco, Calif.
General Aniline & Film Corporation, New York, N.Y.
General Electric Company, Chemical & Metallurgical Division, Pittsfield, Mass.
General Tire & Rubber Company, The, Wabash, Ind.
Goodrich, B. F., Chemical Company, Cleveland, Ohio
Goodyear Tire & Rubber Company, Akron, Ohio
Grace Chemical Company, New York, N.Y.
Gray Stamping & Manufacturing Co., Plano, Ill.
Handy & Harman, New York, N.Y.
Harshaw Chemical Company, The, Cleveland, Ohio
Harvey Machine Co., Inc., Torrance, Calif.
Hercules Powder Company, Wilmington, Del.
Heyden Newport Chemical Corporation, New York, N.Y.
Hooker Eletrochemical Company, Niagara Falls, N.Y.
Industrial Rubber Goods Company, St. Joseph, Mich.
International Nickel Co., Inc., New York, N.Y.
International Salt Co., Inc., Scranton, Pa.
International Silver Company, The, Meriden, Conn.
Jefferson Chemical Company, Inc., Houston 1, Texas
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Kennecott Copper Corporation, New York, N.Y.
Kilgore, Inc., Westerville, Ohio
Koppers & Company, Inc., Pittsburgh, Pa.
Kwikset Locks, Inc., Anaheim, Calif.
Lambert-Hudnut Mfg. Laboratories, Inc., Lititz, Penna. subsidiary of Warner-Lambert Pharmaceutical Company, St. Louis, Mo.
Eli Lilly and Co., Indianapolis 6, Ind.
Little, Arthur D., Inc., Cambridge, Mass.
Mason, L. E., Company, Hyde Park, Mass.
Merck & Company, Inc., Rahway, N.J.
Miles Laboratories, Inc., Elkhart, Ind.
Mine Safety Appliances Co., Pittsburgh, Pa.
Minnesota Mining & Manufacturing Co., 900 Fauquier Avenue, St. Paul, Minnesota
Miracle Adhesives Corp., 250 Pettit Ave., Bellmore, Long Island.
Monarch Aluminum Mfg. Co., Cleveland, Ohio
Monsanto Chemical Company, St. Louis, Mo.
National Fireworks Ordnance Corp., West Hanover, Mass.
Niagara Blower Co., New York, N.Y.
Oldbury Electro-Chemical Co., Niagara Falls, N.Y.
Olin Mathieson Chemical Corp., East Alton, Ill.
Oronite Chemical Company, San Francisco, Calif.
Parsons, Ralph M., Company, The, Los Angeles, Calif.
Pemco Corporation, Baltimore, Md.
Penick, S. B., & Company, New York, N.Y.
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Pfizer, Chas. & Company, Inc., Brooklyn, N.Y.
Philco Corporation, Philadelphia, Pa.
Phillips Petroleum Company, Bartlesville, Okla.
Pittsburgh Coke & Chemical Co., Pittsburgh, Pa.
Proctor & Gamble, Cincinnati, Ohio.
Reynolds Metals Company, Louisville 1, Ky.
Scovill Manufacturing Company, Waterbury, Conn.
Shea Chemical Corp., Jeffersonville, Ind.
Shell Chemical Corp., Denver, Colo.
Shell Development Company, Emeryville, Calif.
Sheller Mfg. Co., Dryden Rubber Div., Chicago, Ill.
Shwayder Bros., Inc., Denver, Colo.
Standard Oil Company (Indiana), Chicago, Ill.
Stauffer Chemical Company, New York, N.Y.
Sun Oil Company, Philadelphia, Pa.
Union Carbide & Carbon Corp., New York, N.Y.
United-Carr Fastener Corp., Cambridge, Mass.
United States Rubber Company, New York, N.Y.
Universal Match Corp., Ferguson, Mo.
Vitro Corporation of America, New York, N.Y.
Vulcan-Cincinnati, Inc., Cincinnati, Ohio
Warner-Chilcott Laboratories, Morris Plains, N.J
Witco Chemical Company, Chicago, Ill.
Wyandotte Chemicals Corp., Wyandotte, Mich.
Zaremba Company, Buffalo, N.Y.
Zenith Aircraft, Div. of Zenith Plastics Co., Gardena, Calif.

Companies listed in bold face type are Sustaining Members

CHEMICAL WARFARE SUPPLY SWPA WORLD WAR II

By IRVING R. MOLLEN, Lt. Col., CmlC.

(This is the second and concluding installment of Colonel Mollen's article on chemical supply operations in the Southwest Pacific area during World War II. The previous installment, published in the March-April issue, told of the establishment in 1942 of the Chemical Section at SOS headquarters at Melbourne, Australia, and of its subsequent movements northward as the war progressed. It referred to some of the special problems of chemical supply and maintenance and their solutions as not always "in the book" and alluded to the cordial working relationship between the Chemical Section and the SOS and GHQ administrative headquarters, USAFFE.)

THE SWPA CHEMICAL CORPS INSTALLATION early established the policy of complete cooperation with the other services and with our allies, and this policy paid off handsomely. As an example, in the New Guinea-Buna-Gona Campaign, it was learned that, in addition to fighting the Jap, we had to fight another enemy—malaria. The large number of men coming down with this disease was affecting our ability to put men in the field to successfully complete our mission. Knapsack-type sprayers were urgently needed to spray infested swampy areas to destroy the breeding place of the anopheles mosquito, carrier of the disease. The Engineers, however, were unable to supply sprayers. Permission was granted by the SOS Chief Chemical Officer to issue and utilize the CW 3-gallon decontaminating apparatus for the purpose. The letter quoted from the Theater Malariologist will show the important part that apparatus played:

"HEADQUARTERS

UNITED STATES ARMY FORCES IN THE FAR EAST

GLO/vw
APO 501
7 May 1945

"SUBJECT: Departmental Commendation

"TO: The Chief Chemical Warfare Officer, Headquarters, USAFFE, APO 501.

"1. It is my pleasure to convey the thanks of all malaria control personnel to the Supply Section C.W.S. for a job well done. Without the generous support of your service in providing the Malaria Control Units with 3 gallon decontaminating apparatus it would have been difficult to do the spraying of oil necessary for mosquito control. Throughout New Guinea and the Philippines the C.W.S. was our main source of supply of sprayers. The cooperation that was shown by supply officers in each base is highly commendatory. The stocks were often earmarked for other Chemical Warfare projects, but the officers always shared the supply, going short themselves oftentimes.

"2. This cooperation has aided materially in the control of malaria in the SWPA. Undoubtedly operations in general would have been more difficult and establishment of bases slower due to malaria if there had been no source of obtaining knapsack sprayers.

s/ G. L. Orth
t/ G. L. ORTH
Colonel, Medical Corps
Chief Malariologist"

"1st Ind.

"FEGD 330.13

"HEADQUARTERS, USAFFE, APO 501, 9 May 1945

"TO: Commanding General, USASOS, APO 507

"By command of General MacARTHUR:

s/ M. B. Kendrick
t/ M. B. KENDRICK
Lt. Col. A.G.D.
Asst. Adj. Gen."

Theater levels of this apparatus for use in the event of gas warfare took into account the very large issues made for malarial control. This issue had the approval of the Chief Chemical Warfare Officer, Washington, D.C.

Such cooperation was also in evidence in the issue of the chemical service trucks. As a result of the shipping problem, it often took six months before a truck available in one base could be shipped to a chemical unit in another base. In addition, CW did not possess the facilities for the processing, servicing, and maintenance of these trucks prior to their issue. The basic truck was the same as other basic 6x6 trucks, which were stocked by Ordnance for regular issue. Accordingly, an agreement was worked out to turn over to Ordnance any such trucks received from the States. They, in turn, were to issue CW an equivalent 6x6 truck as needed in bases specified. This saved shipping, and enabled us to issue our units new trucks rather than those which had been held in stock for six months to a year. The chemical equipment for such trucks was handled, issued and stored by CW.

THE ADVANTAGE OF COOPERATION between the services was also evidenced in procurement of parts for power-driven decontaminating apparatus. Maintenance of adequate stocks of spare parts for the various makes of this apparatus was a constant problem due to nonavailability or to having a part for one type when another was required. Through arrangements with Ordnance, Jeep engines were procured and used for replacement when the original power-driven engines were not economically repairable. The latter were removed and cannibalized for parts. Another advantage of this arrangement was that the spare parts for the jeep engine were much more readily available and could be supplied by Ordnance.

Still another example was found in the method of obtaining cylinders of nitrogen and hydrogen, which originally came from the States or from Australia. In many cases, by the time the cylinders arrived at forward

bases, the pressure had fallen below the minimum required. We were able to overcome this condition in the hydrogen cylinders and bring them up to needed pressure by the utilization of the Signal Corps portable hydrogen generator which was designed for filling balloons. Also, the Engineers had sent oxygen plants to the forward area and these plants would fill the nitrogen cylinders for us. Later, when only compressed air was required for the M11 flame thrower, the Engineers filled those cylinders, eliminating the long haul back to Australia or the States, and enabling more effective utilization of available cylinders.

Various other items were exchanged with or issued to other services to mutual advantage, the governing criteria being the best interest of the war effort. It is not intended to imply that wholesale quantities of various items were given away or received. Generally, only nominal amounts were involved and, in cases where quantities were large, concurrence and approval was either received from the Chief, Chemical Warfare Service, Washington, D.C., or from the Theater Commander. Such transfers were also effected between the Navy, the Air Force, and the fighting forces of our Allies.

Although Australia was not as highly developed industrially as the United States, there were numerous plants capable of manufacturing items needed by all the services. A large number of products never manufactured previously in that country were made and supplied to the United States Armed Forces. The advantages of local procurement, especially when one is at the end of a 10,000-mile pipeline, does not have to be overemphasized. We were able to procure items such as chloride of lime, chlorsulfonic acid, gas resistant sacks, spare parts, chemicals, and various special items as needed. In addition to supplies and equipment, labor was also furnished the services through reverse lend lease.

MANY SECONDARY non-chemical warfare uses were found for much of our offensive and defensive equipment, such as previously described for the 3-gallon decontaminating apparatus for malaria control. Such use was fostered and encouraged where it did not affect our ability to meet the primary objectives and missions of the service.

When adequate water supply and distribution in the various bases and areas was of major concern to the Command, the power-driven decontaminating apparatus proved most effective in helping to overcome this problem. In Milne Bay, New Guinea, the 28th Chemical Decon Company took over the operation of the entire base water distribution system, utilizing power-driven apparatus. The job was so well done that the unit was highly commended by the base commander. As a result, the number of power driven decons issued this unit and other CW units was increased over the original authorized allowance.

This particular case proved to be a boon to Chemical Warfare. Normally, discipline with such specialized units as the 28th Chemical Decon Company became a problem after a time due to lack of specific missions in non-gas warfare. Performance of such jobs as described above improved the morale of the troops concerned and made them feel as though they were making a definite contribution to the war effort.

Use was also made of the various chemical processing companies in the theater when they were not performing their original function, i.e., impregnation of clothing. The M2 plants were utilized as laundries and the M1 plants as dry cleaning plants. (Note: M1 plants in the theater were returned to the States as rapidly as they were replaced by the M2 plants.) Such use aided in familiarizing personnel with the operation of their equipment. It should be emphasized here that these specialized units were spending a great deal of their time, when not occupied with their particular mission and training, in assisting other CW organizations in the performance of their tasks. Such additional jobs as described benefited all concerned. The new composite type units which began to arrive in the theater at a later date proved to be the answer to the problem of the specialized unit.

As previously stated, jungle warfare very early showed up defects in some of our equipment and supplies. The first actual use of the flame thrower in combat ended disastrously, resulting in the death of the operator. Moisture had permeated the electrical system and pressure cylinders were defective. Immediate steps were taken to prevent a recurrence by waterproofing the entire electrical system of the M1A1 flame thrower. Special checks and tests were added to those previously performed to insure combat serviceability. The 10th Chemical Maintenance Company, with Capt. John Shaffer commanding, contributed greatly to the success of the program. In addition to helping to develop the waterproofing and testing procedure, this unit also initially instructed personnel of combat units in the operation, maintenance, firing and filling of the flame thrower. The program proved very successful and its effectiveness was aided considerably by Lt. Colonel McKinney, Assistant Chemical Officer of the Sixth Army.

ANOTHER LARGE MODIFICATION job was the waterproofing of the training masks. Combat units early felt the need for a mask that would be primarily lightweight, endurable, and still serviceable after being immersed in water, as in landing operations. The training mask, modified to include these requirements, seemed to fill the bill. The 42d Chemical Laboratory Company under the supervision of Lt. Colonel Enz, CW SOS Technical Officer, developed the following procedure:

The canister was completely disconnected from the facepiece and a cork was placed in the neck of the canister. To prevent its loss, the cork was tied to the outside neck of the canister. A milk bottle-type stopper, with a tab to facilitate quick removal, was inserted in the bottom of the canister. Both items were removed prior to reinsertion of the canister into the face-piece before use. A specially designed clamp was attached to the bottom neck of the facepiece. This served to make an airtight seal between the facepiece and the canister when the latter was reinserted into the facepiece. Spare corks and stoppers were also furnished. The mask was accepted wholeheartedly by combat troops and was used in all landing operations until it was replaced by the lightweight service mask.

Another field adaptation which proved most helpful was engineered by the 10th Chemical Maintenance Company. We had many types of commercial cylinders of hydrogen, nitrogen, or compressed air available in the theater, but each type of cylinder had a different thread. Adapters permitted us to use numerous cylinders regardless of thread, thus relieving the serious shortage of cylinders and permitting wider use of flame throwers in the theater.

Supply was able to accomplish its mission only because of the support it received from other branches of the Office of the SOS Chief Chemical Officer and the cooperation received from Base Chemical Officers, and the Chemical Officers and CW units of all Commands. The list of all such organizations and units that played

an important part in CW activities in the SWPA (supply or otherwise) is too numerous to give here.

However, one activity deserving special mention was the CW School which was organized and operated under SOS. Established early in 1942 at Brisbane, Australia, under the able direction of Capt. Carl V. Burke, this school trained large numbers of Air Force, ground, and SOS personnel, both commissioned and enlisted. Its enviable record is attested to by the number of requests from officers for permission to attend. Many officers recent from combat considered the two-week assignment to the school as a reward, even though it required concentrated study and hard work. Consideration was given to the quality and preparation of food and quarters accommodation, which kept morale high and helped to insure that the student got the most out of the school. In turn, these officers were of great help to the CWS in selling the chemical program to their organizations and insuring preparedness.

ANOTHER UNIT was the 42d Chemical Laboratory Company, which was originally destined for the Philippines and was on the high seas when war began, having just left Pearl Harbor about two or three days before December 7. It, along with other units, was diverted to Australia and arrived there on December 25, 1941. Although very highly specialized, this unit proved most useful to the theater. For a long time, it was the only Army technical research unit in the SWPA capable of doing laboratory work. Included among the multiple projects given it were the preparation of various skin dyes and supervision of the dyeing of various types of Camouflage clothes urgently needed in jungle combat. Later, this unit helped prepare dibutylphthalate which was needed to protect against ticks and to minimize a typhus outbreak. These are just a few of the projects this outfit handled in addition to being kept constantly busy performing multiple chemical, physical, and surveillance tests for all services.

In the early days, the SWPA CW Officer had to justify his position many times a day and exert every effort possible not to be assigned to other duties. In many cases, reception was not too favorable to the training program he suggested, and his problems were greatly accentuated by the completely indifferent manner with which many units treated their chemical equipment. As time went on, the theater began to realize through the many activities in which Chemical Warfare was involved —such as training and the results achieved by the school and other CW organizations; the cooperativeness with the other services; and the new weapons, including the flame throwers, the 4.2" mortar, the white phosphorous grenades, napalm incendiary bombs, smoke grenades, both white and colored—that the Service had an important mission in the non-gas warfare phase as well as in preparing for eventual use of gas if and when necessary. As a result, personnel were soon treated with greater respect and their suggestions and any advice given were treated with greater regard.

In closing, a description of a very amusing incident which took place illustrates the varied problems with which a Chemical Supply Officer was often faced. The 42nd Chemical Lab Company which was based in Brisbane had an urgent need for white rats. The best source of these rats was Sydney and, as a consequence, the Chemical Officer of Base 7 was assigned the task of procuring some. As previously stated, transportation in Australia at best was most trying, and regardless of the manner of shipping, a large number of rats and mice invariably died before arrival. Complaint after complaint on this subject from the Lab Company harassed the poor Chemical Officer of Base 7. The letter quoted below was an effort to prevent such complaints, and the indorsement thereto is classic:

"HEADQUARTERS
UNITED STATES ARMY SERVICE OF SUPPLY
OFFICE OF THE CHEMICAL OFFICER

IRM-am
GSCW: 400 APO 501
27 July 1943

"SUBJECT: White Rats

"TO: Chemical Officer, Base Section No. 7, APO 927

"1. Request that fifty (50) white rats be procured and shipped, via air, to the 42nd Chemical Lab Co., APO 923.

"2. It is suggested that the 42nd Chemical Lab Co. be notified by phone just prior to shipment of the rats, so that a member of this organization can meet the plane when it arrives.

"3. Proper precautions should be taken with reference to packaging, and food should be provided.

"For the Chemical Officer:

s/ Irving R. Mollen
t/ IRVING R. MOLLEN
Major, C.W.S.
Supply Officer."

"1st Ind.

"OFFICE OF THE CHEMICAL OFFICER, HQ BASE SECTION 7, APO 927, 31 July 1943

"TO: Chemical Officer USASOS APO 501

"1. Forwarded.

"2. They left this morning, two Sibley Stoves were in the package and each rat had been issued with a suit of long red woolen underwear. Each rat was also issued with one pound of limburger cheese and two bottles of beer. They sure did hate to go.

s/ Arthur H. Williams, Jr.
t/ ARTHUR H. WILLIAMS, JR.
Capt., C.W.S.
Chemical Officer B/S 7"

AIR RESEARCH & DEVELOPMENT

(Continued from page 14)

Western Development Division in Inglewood, California, manages the Air Force's top priority program—development of ballistic missiles. Assisted by highly qualified experts of the Ramo-Wooldridge Corporation, WDD coordinates the efforts of some 75,000 personnel employed by hundreds of prime and sub-contractors for the development of the ATLAS and TITAN Intercontinental Ballistic Missiles and the THOR Intermediate Range Ballistic Missile.

At the other end of the spectrum—testing of hardware—ARDC provides its contractors with test facilities the scope of which would be far beyond the economic capabilities of non-government organizations.

At Patrick Air Force Base, Florida, for example, ARDC's missile test center operates a completely instrument test range stretching over 1,000 miles—and, ultimately, 5,000 miles—down the Atlantic Ocean to British-owned Ascension Island. The range also serves as a testing ground for certain U. S. Army and Navy missiles.

At the Arnold Engineering Development Center in Tullahoma, Tennessee, huge wind tunnels permit testing of full-size jet and rocket engines at simulated altitudes up to 80,000 feet. At the Air Force Flight Test Center, in California's Mojave Desert, a vast dry lake provides miles of hard landing surface needed for testing the airplanes of tomorrow.

Research

Air Force defines research as the "fundamental investigation of all activities wherein the discovery of applications of interest to the Air Force may be expected."

ARDC's research is conducted command-wide, and is integrated around broad scientific objectives which lie in the following areas of interest to the Air Force: propulsion, materials, electronics, geophysics, bio-sciences and aero-mechanics. Presently, Research Planning Objectives are in process of formulation on ARDC's basic interests in these research areas. These fundamental documents will point up the specific areas of ARDC scientific interests for the guidance of all scientific endeavors by ARDC.

Most ARDC centers carry on the search for pertinent new knowledge and new military concepts arising from scientific advances. For example, the Air Force Cambridge Research Center supports research in fields related to electronics, geophysics, and human engineering; The Air Force Personnel and Training Research Center supports research in personnel evaluation, testing, and human behavior in general.

Of particular note is ARDC's Air Force Office of Scientific Research whose sole interest is *research*. AFOSR was set up to fulfill a need for early research which is so vital to the country if the Air Force is to maintain its qualitative lead in weapon systems. Today, AFOSR supervises approximately 600 research contracts. Most of the office's contracts are with universities because its projects are concerned with basic scientific investigation.

AFOSR's mission is threefold: (1) Plan, initiate and manage an exploratory research program to provide new scientific knowledge which may result in significant new concepts of air warfare and steady improvement of aerial weapon systems and their use in air warfare; (2) Recognize the implications and possible application of significant scientific advances and technological "breakthroughs"; (3) Recommend to ARDC headquarters plans, policies, and procedures to encourage and stimulate research and enhance relations with the scientific community.

Just as development people give thought to research while they are busy developing, AFOSR must peer deep into the future to envision Air Force needs 40-50 years away while it works, at the same time, more directly on problems which will affect the Service 10-15 years from now.

Technical Development

The Technical Development program in ARDC is "the exploration and knowledge, materiel, and techniques to obtain an experimentally demonstrated capability to satisfy an existing or anticipated operational requirement. Technical developments are not normally identifiable with an existing or planned system or component thereof. The end product may be an experimental model to 'prove-out' functional adequacy."

The technical development program includes the technical program planning document (TPPD) release program established under the Air Force-Science-Industry team concept.

TPPD's are a series of studies covering broad functional areas such as bombing, navigation, bomber defense and similar subjects. In each area the TPPD includes:

"A statement of the operational or functional military problem and the aspects of the problem toward which planning must be directed.

"An evaluation of present technical capabilities and the limitations in the performance of materiel and techniques associated with the problem.

"A review of innovations and avenues of scientific approach to the improvement of present capabilities toward future requirements.

"A statement of the requirements for the Technical Development Program, setting forth the time-oriented performance objectives."

The product gained, as a result of achieving the military objectives described in each TPPD, are experimentally demonstrated techniques and capabilities. These later may be development-engineered into specific items of materiel to meet future operational needs. Work in these technical areas is aimed at the second generation of weapons—those which will be needed in the next five to ten years.

In fulfilling its technical development mission under the team concept and thereby increasing the probability of technological breakthroughs, ARDC initiated the TPPD Release Program. The documents, many of which are classified, are being released to organizations according to their individual research and development interests, capabilities and security statii.

Operational Support Development

Briefly stated, operational support development is defined as "the development of those items of equipment, materiel, or techniques not normally associated with a weapon system but required for the support or operation of weapon systems or other U. S. Air Force functions."

In the past, many items of materiel, equipment and techniques, developed strictly for commercial use, could be modified to meet military requirements. The policy still is in existence.

From the military standpoint, the philosophy is sound. By using commercially developed items, duplicate development efforts are eliminated, and the time required for providing the right quality and quantity of air power is shortened.

As members of the Industry-Air Force team, many

manufacturers offer their products to the Service for possible military application.

ARDC personnel determine whether or not the commercial product can be given military application and in what areas. If the product has Air Force application, ARDC personnel take action to procure the equipment for necessary modification and testing to meet Air Force requirements.

After successful completion of functional testing by ARDC and subsequent operational testing by the Air Proving Ground Command, the commercially developed item is formally approved for procurement. Procurement in production quantities is the responsibility of the Air Materiel Command at Wright-Patterson Air Force Base, Dayton, Ohio.

Systems Development Program

A major segment of ARDC's activities is carried on under what is known as the "weapon system concept."

A weapon system is a composite of equipment, skills, and techniques that form an instrument of combat which usually, but not necessarily, has an air vehicle as its major operational element. The complete weapon system includes all related equipment, materials, services and personnel required solely for the operation of the air vehicle, or other major element of the system, so that the instrument of combat becomes a self-sufficient unit of striking power in its operational environment. The definition includes the air vehicle with its airframe, power plant and fire control; bombing; navigation; flight control; electrical ground and training equipments; and personnel training programs.

Stated another way, the weapon system concept is based on the recognition of the complexity of modern Air Force instruments of combat, and is, therefore, a management concept which provides for plans, schedules and controls of a weapon system from design through its life as an operational entity—the air vehicle, its components, supporting equipment, and the preparation for its use.

Headquarters, U. S. Air Force, determines both the need and formulates broad development guidance for weapon systems. Specifically, a broad evaluation of a need is made by a little known and even less publicized group of officers and civilians within the Office of Development Planning of the Air Staff. From the day-to-day activities of the Air Force, this small, select group peers into the future, keeping the country's security in constant focus.

During their analysis, members of the group contemplate many critical factors which include our military strategy and tactics; war plans; the military, technical and scientific capabilities of other world powers; and the state of our science and technology. Both the present and future potential of all these categories are thoroughly dissected and evaluated. In some instances, the potential is projected far into the future.

Working jointly with ARDC, the Office of Development Planning in the Pentagon prepares a Development Planning Objective after carefully considering all approaches to the problem. The DPO describes the capabilities of the air weapon required to support the strategic, tactical and air defense missions of the Air Force. Projected to from five to 15 years, the DPO probes the technical feasibility of the weapon, the while considering the enemy's probable capabilities in the same area. Lastly, it establishes a deadline when all objectives must be met.

After Air Staff approval, ARDC uses the DPO to set up technical programs for the development of long-lead items for the weapon system. When necessary, ARDC reorients the programs to keep them consistent with other development planning objectives.

Now, a general objective has been set. What is then needed is a more specific plan for a complete, combat-ready system for the future. At this point, a General Operational Requirement is published. The GOR describes the operational need for a weapon to fulfill a specific mission. While the GOR specifies the operational need for the weapon, it does not spell out the means of meeting the requirement.

After ARDC headquarters reviews the GOR, it establishes a development policy and provides guidance in the various technical areas to be explored as possible solutions to fulfill the requirement. Based on this review, ARDC may contract with private industry for one or more General Design Studies of a weapon system which will fulfill the requirement. GDS's explore possible technical and scientific approaches to the problem.

After reviewing all design studies, ARDC later prepares a Development Plan—a step-by-step schedule for the complete system and its major components. The funds required are estimated and incorporated in the DP. Accompanying the plan is a General Design Specifications which details the configuration of the basic weapon system, its guidance and control system, its armament and other components—including ground-handling facilities.

The Air Staff reviews the Development Plan. When approved, it is returned to ARDC for implementation. A Weapon System Project Office (WSPO) then is established though at that time it may be made up of only a few people.

Selection of eligible contractors for design involves a joint ARDC-AMC review. The newest approach is a "Source Selection Board," chaired by the ARDC Director of Weapon Systems Management. The board was established to eliminate, as much as possible, the time-consuming design study period previously required as part of the competitive initiation of the development cycle.

Using information maintained by AMC on contractors' facilities and capabilities, the board is able to reduce the large number of potential contractors to those capable of performing the required work. Then, using brief management reports covering technical approach facilities, manpower, workload, et cetera, the board further reduces the number of contractors to the minimum consistent with the risk involved in the program, i. e., the urgency and the advances required in the art of weapon system development.

Both the final selection of design contractors and the decision upon the scope of the design contract also are subject to variations in procedure. Headquarters USAF, ARDC and AMC participate in the selection. The joint proposals of ARDC and AMC, supported by the findings of the Source Selection Board, are submitted to Headquarters USAF. After the Air Force deputy chiefs of staff and higher authorities (Chief of Staff, Secretariat), review and approve the recommendations made, a project priority is assigned and an authorization is issued to ARDC to proceed with the project.

Following contractor selection, the WSPO assumes the entire workload of managing the program. Immediately, technical requirements are established and contracts issued. These actions are followed by continuous contact with the technical personnel of ARDC centers and the contractors involved—not only the weapon system contractor but also the subsystem and equipment manufacturers who provide parts of the system directly to the weapon system contractor and through direct government procurement.

Meanwhile, all these activities generate development engineering inspections which involve interested representatives from commands and organizations outside ARDC. The AMC members of the WSPO are now concerned with production engineering problems, government furnished equipment scheduling, and training equipment procurement.

Finally, as the design becomes firm, a Mockup Inspection is conducted and, after the detailed engineering and fabrication period, results in a Contract Technical Compliance Inspection which normally is scheduled prior to the first flight of the air vehicle.

During the testing period, production is continued at a slow rate and the changes determined by testing modified requirements and improvements in installations are a major portion of WSPO's work. Coordination with other agencies continues—especially in the maintenance, supply, operational and training areas.

Normally, the WSPO is reduced in size as production nears completion, and the executive responsibility is transferred within AMC to Lead Air Material Area (LAMA) responsible for the particular system. ARDC engineering support activities are continued, although the trend is to have this type of support provided by LAMA so that ARDC manpower can be devoted to the new development both in techniques and weapon systems.

Finally, the weapon systems enters the U.S. Air Force operational inventory.

Conclusion

For the foreseeable future, ARDC will continue its mission of developing air weapon systems of superior quality.

We cannot have less and survive. Perhaps there is an answer to world peace that is definite in tone and positive in content. We know that war is not the answer. But if we would have peace, superior air power is our best insurance. If we are to be attacked, then supreme air power is the primary solution to our survival.

In brief, it is the ARDC mission to provide this superior airpower. Our goal is a challenge to men of vision, wisdom, and faith in the future. For should the day dawn when we must defend our country in another war, we know it will come with a startling and stunning swiftness.

Time, calculated not in weeks, or months, but in days, hours, even minutes, well may decide the issue.

At such a moment, the first call would be for retaliation—enough superior air power to deaden the will of the enemy to resist.

This, then, is the eventuality for which we must be prepared 24-hours-a-day, 7-days-a-week, 365-days a-year.

MORE AIR POWER

(Continued from page 23)

struction and is composed of glass cloth impregnated with polyester resins. Similarly, jet plane escape capsules presently being investigated are made of a honeycomb structural material reinforced by plastics.

An application of plastics to aeromedicine has been the development of a spray device that quickly sprays a protective dressing of plastic material over a burned area of skin and gives the advantages of observability without removal. This would be quite valuable for treating the thermal casualties from atomic bombings.

Elastomers. Problems exist also concerning elastomers or synthetic rubbers. Rain erosion of exterior plastic parts of planes is an example. For speeds under supersonic a satisfactory solution has been the application of protective coatings such as elastomers, as in the coating of radomes with neoprene compounds. Previous coatings have not been able to withstand temperatures in excess of 350° F. Higher speeds will result in higher temperatures, and passage of hot gases through specially constructed radomes to prevent ice formation has also resulted in requirements for better coatings. Lactoprene compounds have been developed that will function at 500° F. and with the addition of certain additives also withstand rain erosion. Other compounds such as teflon are also being investigated for use as coatings.

Specialized elastomers are needed where synthetic lubricants are used, as these lubricants are more destructive to rubber than are hydrocarbon lubricants. It is expected that lubricants in the future may reach 800° F. in temperature and will require better synthetic elastomers.

Embrittlement is a problem applying to elastomeric materials. At very low temperatures such materials undergo a change in internal structure and pass through what is called a transition point. New properties are then possessed. This is illustrated by the demonstration where a rubber ball is placed in liquid air to become brittle and break into a thousand pieces when dropped. To a less degree this could happen to a canopy seal or the seals for windows and doors, or even to the plane's tires. Commercial demand has not existed for synthetic rubber to meet this requirement of low temperature embrittlement. Consequently, it has been a problem of the armed services. In an effort to develop suitable elastomers the Air Force has sponsored research on such items as fluorocarbon polymers and other fluorine-containing elastomers. Requirements exist for research to develop elastomers that retain elasticity and solvent-resistance from −100° F. to near 800° F.

Metals. As the Arctic area will play a decisive role in future operations we must learn to operate in cold weather and in darkness. Electronic navigation places a heavy premium on reducing weight and space requirements. Discovery of the transistor will aid materially in obtaining this reduction and thus increase our air power with respect to capability for all-weather and night operations. The transistor is a bit of metal such as germanium or silicon with small calculated amounts of impurities such as arsenic. In certain applications it can replace the much larger vacuum tube. It is reliable and operates on about one millionth the electric power that the ordinary vacuum tube requires. Thus, it could materially aid electronic navigation for all-weather and night operations. A transistor recently developed by Bell Telephone Laboratories provides broadband high-frequency amplification and is applicable to FM, TV, telephones, guided missiles and electronic computers.

The chemist and the electronic engineer have cooperated to develop printed circuitry. This is extremely important in miniaturization programs as it cuts down on the space requirement needed by conducting wires. This circuitry involves printing a metallic overlay on a plastic plate. As a Wright Air Development Center pamphlet states: "It is not unusual to find an electronic scientist, a chemist and a mathematician working together on a common problem."

Thermal limitations exist with respect to what are called "thermal barriers." Energy is exchanged between the surfaces of aircraft and the atmosphere. A measure of this exchange is the accommodation coefficient which measures the energy exchange between solid surfaces and ambient gases at low pressures. The Air Force's Wright Air Development Center is engaged in research on this problem. Some approximate thermal barriers or temperatures of decomposition or failure for various materials and aircraft components are given below.

Item	Degrees Fahrenheit
Electronic Aids	200
Textiles	350
Dacron	400
Lubricants	450
Fiberglass resin	450
Rubber	550
Titanium	900
Ceramics	5,000

In certain instances steel alloys have been replaced by titanium. Until recently the metallurgy of titanium has been difficult. Recently, however, improved processes have made the metal more available. As can be seen from the table above it functions up to about 900° F.

Photography. The Air Force has had problems in photography not existing for the commercial user. In the past, industrial research has been done largely for the civilian market and has not emphasized the specialized needs of the Air Force such as high-speed film and infrared photography. Recently, the process of xerography has been developed which permits the taking of reconnaissance photographs in areas where high nuclear radiation exists. In ordinary photographic processes the film would be sensitive to this radiation. Chemicals other than silver halides and even non-halide emulsions are being investigated. Means to improve sensitizers and developers have been studied. Recent examples of high altitude photography in the news have proven the value of photographic research, and its application by air power against our enemies can readily be visualized.

Atmospheric Research. An important field of current research concerns space satellites. Full utilization of these will require a knowledge of the conditions that exist in and the exact composition of the upper atmosphere to include the ionosphere and exosphere, regions beyond the stratosphere and troposphere. In this the chemist can assist. The Air Research and Development Command has an active program of geophysical research. A chemical problem that will exist in connection with manned craft in regions even in the vicinity of 100,000 ft. will be that of removing toxic gases and providing oxygen for breathing within enclosed cabins. In the upper atmosphere the possibility exists of penetration into the cabins by poisonous gases. Ozone is a deadly poison and exists in a large layer of about 75,000 to 100,000 ft. At about 70 miles altitude the ionosphere commences. This is a region characterized by free electrical charges and their effect on the human should be investigated by biochemists and medical specialists.

The application of chemistry and its allied sciences to air power can thus readily be seen. It has been and is

(Continued on page 44)

EVALUATION OF MOLDED POLYETHYLENE DRUMS IN STEEL, PLYWOOD, AND WIREBOUND OVERPACKS

By KENNETH D. BRUNELLI*
Experimental Engineering Division
Chemical Corps Chemical Warfare Laboratories
Army Chemical Center, Md.

GLASS CARBOYS have been used by the chemical industry for many years to transport corrosive and sensitive materials although these containers when handled are subjected to considerable abuse. Shipments of boxed carboys and carboy bottles to Department of Defense agencies have sometimes shown greater than a 10% breakage factor. Other common disadvantages of these carboys are the care required in handling and the difficulty in stacking and tiering. Turning to industrial container firms for cooperation in this problem, the Chemical Corps was informed that large size molded polyethylene drums had been commercially developed as shipping containers for corrosive and sensitive materials and were soon to be available in regular supply.

For sustaining greater handling abuse, these plastic containers in 55-, 30-, and 10-gallon sizes, were tailored to fit into standard steel, fiber and plywood drums. A five-gallon size was also available with a specially designed steel over-pack. It was proposed by the manufacturer that these containers be used in lieu of glass carboys with wooden over-packs and with a view to resolving the problem of excessive breakage in carboy shipments, the Chemical Corps decided to evaluate the plastic containers for this purpose.

The primary objective of initial tests on the molded polyethylene drums was to check the durability of both the basic unit and its over-pack. Under simulated conditions paralleling hazards of transportation and storage, filled polyethylene drums packed in outer containers were subjected to physical drop, vibration, and incline-impact tests.

Twenty (20) molded polyethylene drums, in 55-, 30-, 15, and 5-gallon sizes, were used for the tests. Eighteen (18) of the units tested had rigid over-packs, while the remaining two units had no over-packs. Steel over-packs, plywood over-packs and wirebound crates were used as outer containers for the polyethylene units. Fig. 1 shows representative types of over-packs for molded polyethylene drums.

Apparatus for testing the polyethylene units included a 5,000-lb. L.A.B. package-testing machine and an incline-impact tester.

The procedure for testing the units was as follows:

1. Eighteen molded polyethylene drums with over-packs and two plastic units without over-packs were rough-handled. Rough-handling tests were conducted in accordance with Chemical Corps Directive 206B which sets forth standard test procedure for determining adequacy of packaging and packing proposed for Chemical Corps materiel. Each container was filled to 98% capacity with water prior to testing, and tare and gross weights were recorded.

2. The following sequence of tests was performed on plastic units except as noted:

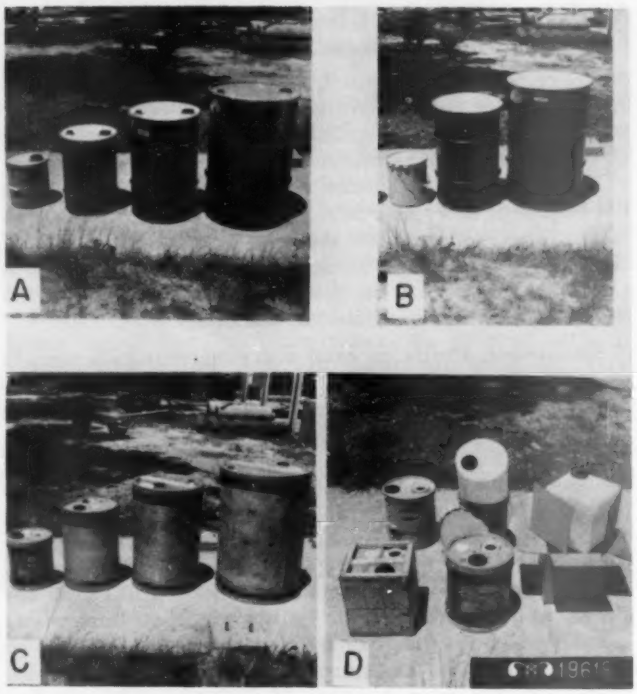


Figure 1—REPRESENTATIVE OVERPACKS FOR MOLDED POLYETHYLENE DRUMS: (A) Open-flange steel over-pack; (B) Solid-head steel overpack; (C) Open-flange plywood drum overpack, and (D) Wirebound crate, open-flange and solid-head steel, and open-flange plywood drum overpacks.

a. A 2-hr. vibration test on the 5,000-lb. L.A.B. package-testing machine at 268 cycles per second (modification of ASTM D999-48T) was performed on all plywood over-packs and half of the steel and wirebound over-packs.

b. A 6-ft. free fall onto solid concrete (modification of ASTM D959-48T).

c. Incline-impact test (modification of ASTM D880-47) performed on over-pack units only.

d. Leakage test (drums were placed on sides for at least 24 hrs. and examined for leaks).

Summarizing the tests conducted on the sample containers, the following observations were made:

1. The molded polyethylene drums without over-packs (fig. 2) exhibited a high degree of burst strength. Of particular significance was the fact that they were able to withstand the severe physical drop test. The drop test, which included puncture drops on a nominal 4 by 4-in. timber, was made at heights exceeding 6 ft.

2. The standard steel drum over-packs, although considerably deformed after test, appeared to give the best overall protection to the plastic drum. With the exception of a 5-gallon steel over-pack, the handle of which caused a puncture leak in the side of the plastic drum, none of the plastic containers in the steel over-packs was damaged.

3. The plywood over-packs did not appear suitable for use with the plastic drums. In addition to severe splintering of the plywood, the metal staples and nails used in fabricating these over-packs punctured the plastic drum. Abrasive damage to plastic sides was also evident after vibration test. Of the two types tested, the solid-end over-pack closure appeared to be more durable than the exposed flange-type closure.

4. The wirebound crate over-packs also did not appear suitable due to the severe fractures and wood-splintering of body and end sections.

5. Severe leaks developed at the plastic plug closures

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* Espp formerly assigned to Chemical Warfare Laboratories.

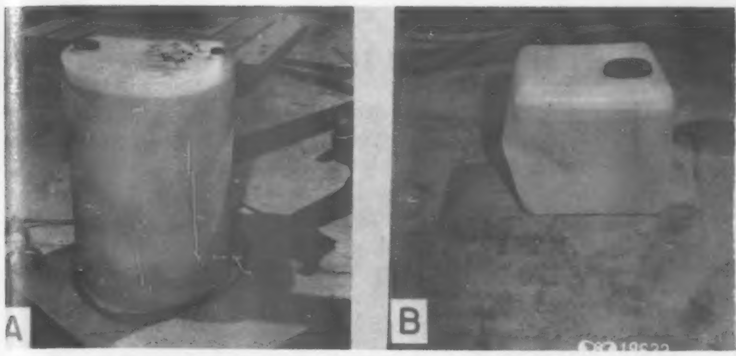

Figure 2—MOLDED POLYETHYLENE DRUMS WITHOUT OVERPACKS AFTER DROP TESTS: (A) The 55-gal. drum and (B) the 5-gal. drum.

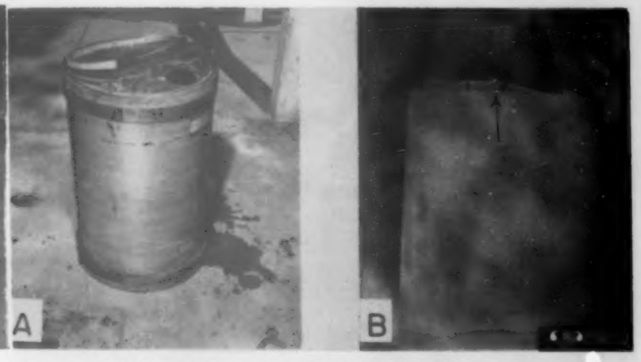

Figure 3—FAILURE OF A 30-GAL. POLYETHYLENE DRUM WITH PLYWOOD OVERPACK: The effects of one diagonal drop on (A) the open-flange plywood overpack, and (B) the plastic drum. The break in the plastic was spread apart with pegs to reveal the extent of damage.

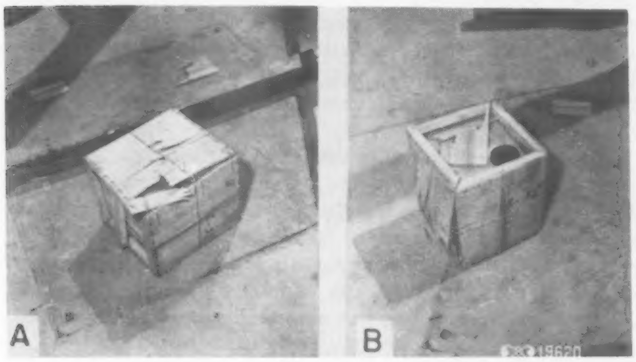

Figure 4—5-GAL. DRUM WITH WIREBOUND CRATE OVERPACK AFTER DROP TEST: (A) After a diagonal and flat drop, and (B) the same unit after a subsequent drop on a nominal 4 by 4 in. timber (puncture drop).

Figure 5—TESTING OF A 15-GAL. DRUM WITH OPEN-FLANGE STEEL OVERPACK: In sequence: (A) diagonal drops; (B) flat drops; (C) puncture drops, and (D) incline-impact test.

Figure 6—TESTING OF A 30-GAL. DRUM WITH OPEN-FLANGE STEEL OVERPACK: In sequence: (A) diagonal drop; (B) flat drop; (C) puncture drop, and (D) incline-impact test.

Figure 7—TESTING OF A 55-GAL. DRUM WITH OPEN-FLANGE PLYWOOD DRUM OVERPACK: In sequence: (A) diagonal drop; (B) flat drop, and (C) puncture drop (failed). Note protruding rim nails and staples on hoop.

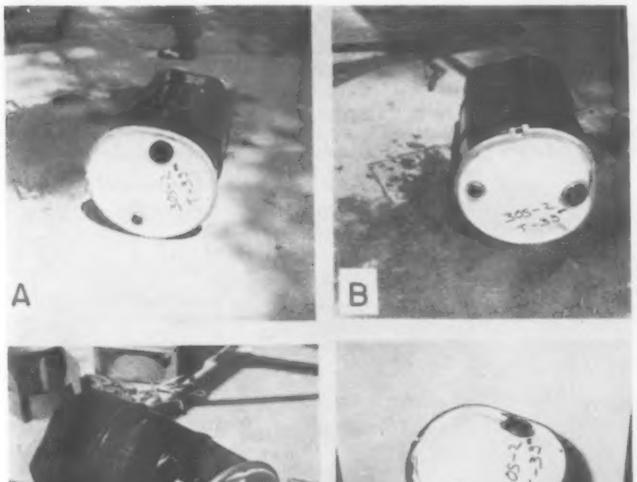

Fig. 5

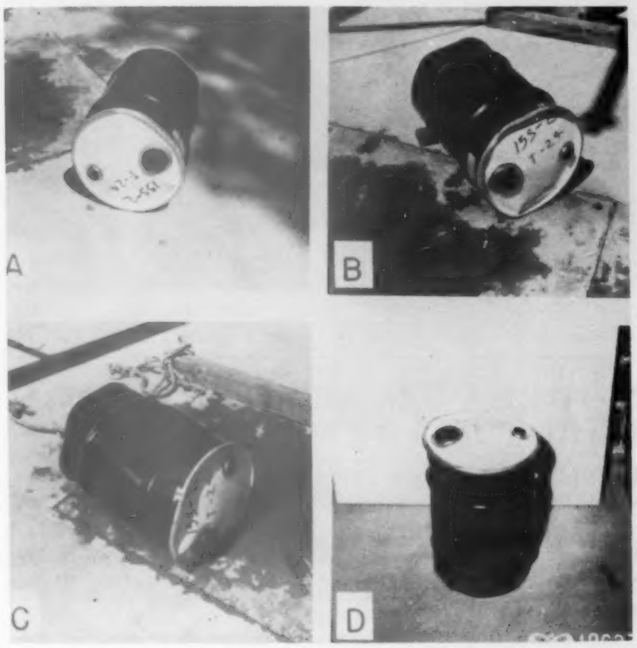

Fig. 6

Fig. 7

—U. S. Army Photos

HOW ARMY SOLVED TWO TRANSPORTATION PROBLEMS

The two pictures herewith show how the Army has adapted two new technological developments in meeting special transportation problems. The picture at the top, taken during recent logistical exercises in France, shows the application of the DeLong Floating Pier in unloading of military supplies from cargo ships without usual dock facilities.

The floating pier with hydraulic retractable piles, designed by L. B. DeLong, can be operated in depths up to 75 feet and does not require a level underwater surface. By means of these "sea islands" to support cable lines and aerial tram-car, the Army exercises showed the feasibility of extensive supply operations over a cliff-lined shore. The sky-car carries 15 to 20 tons of cargo at a speed of 35 miles per hour and is discharged directly into waiting trucks. The exercises demonstrated that cargoes can be beached over practically any terrain, obviating the necessity of either port facilities or the availability of flat sand beaches as characterized over-beach supply in World War II.

Another logistical application of technology is shown in the picture below. In this case the Army and the U.S. Rubber Co. developed rolling containers for liquids of any sort in the form of rubber cylinders and bags equipped with axles and metal yoke device, so that a number of these containers can be towed by a jeep or other vehicle. Each bag has a capacity of 500 gallons and can be towed over practically any terrain.

MODERN U.S. ARMY CHEMICAL DEPOT IN FRENCH BARRACKS

SAMPIGNY, France—A battle-site of three wars and the encampment of soldiers of three different Armies is a relatively small plot of ground near the winding Meuse River. Now this same site is the major issue point for chemical supplies in Europe, the Advance Section Sampigny Chemical Depot.

From the time of the Franco-Prussian War of 1870, the depot has been the scene of battles, occupation and re-occupation by foreign Allied troops. In that period the Prussian Army occupied Sampigny and the barracks there. Following the war, a regiment of "Chausseurs a Cheval," (French cavalry) took possession of the billets.

In the fall of 1914, the French cavalry vacated the depot and a month later it was occupied by the advancing German Army after three days and nights of bombardment.

The Allied offensive in September 1918 saw the small town change hands again, and the American Army under the command of General Pershing liberated the village and moved into the barracks. Later the camp was utilized as a German PW camp.

In 1940, for the fourth time in seventy years, the depot changed hands. It became a German military vehicle repair depot. Then, exactly 26 years after the American Army had previously liberated the city and depot, the Americans returned, this time in tanks; they entered the town without a fight.

After a period of private ownership, the US Army again returned to the depot in January, 1952, and began to rebuild it into what it is today, a chemical supply depot and maintenance repair center for chemical equipment. New facilities such as a barber shop, snack bar, bowling alleys, photo lab and an athletic field have been opened at the depot and winterized hutments for troops have been replaced by prefabricated billets.

The main entrance to the Caserne of the Cavalry in the town of Sampigny, France, near the city of St. Mihiel, scene of heavy fighting during World War I. Near this spot stands the present day Advance Section Sampigny Chemical Depot.

Modern, metal, prfabricated buildings of the Advance Section's Sampigny Chemical Depot have replaced ancient stone buildings which housed the troops of other times. Landscaped plots add a touch of home to the company areas.

CHEMICAL CORPS NEWS

DR. FINKELSTEIN RETIRES AFTER 38 YEARS SERVICE

—U. S. Army Photo

EDGEWOOD, MD. — Dr. Leo Finkelstein, physical chemist and consultant on aerosols and incendiaries at the Chemical Warfare Laboratories, Army Chemical Center, retired on January 31 after more than 38 years of government service, 33 at this post.

Dr. Finkelstein is an alumnus of the Illinois Institute of Technology with a degree in chemical engineering. He received a doctor's degree from the University of Chicago where he majored in physical chemistry and physics.

When World War I started, he volunteered his services as a civilian in gas warfare research. He joined the Army in 1917, was commissioned a second lieutenant and was assigned to the American University Laboratory in Washington, D. C., where the chemical warfare research program originated. In 1918, he was sent to France to become chief of the Division of the American Expeditionary Forces laboratory in Paris.

From 1920 until 1923 he worked for the Bureau of Mines experimenting there with helium for use in dirigibles. In 1924, he came to the Chemical Center, or Edgewood Arsenal as it was then called. Dr. Finkelstein holds many patents on smokes, incendiary compositions, and testing devices.

DR. FREDERICK M. LANE RETIRES

EDGEWOOD, MD.—Dr. Frederick M. Lane, assistant for technical coordination in the Directorate of Development, Chemical Warfare Laboratories, retired recently after completing 37 years of government service, 29 at the Army Chemical Center.

A native of Springfield, Masachusetts, Dr. Lane is an alumnus of Massachusetts Institute of Technology and has a PhD degree from Yale.

Before coming to the Chemical Center in 1929, he was with the Bureau of Mines for nine years as a petroleum chemist, and before that he taught organic chemistry at MIT, University of Maine, and Yale.

At the Chemical Center, he was made chief of the clothing department, protective division, and it was through his work that protective clothing became an item of defense.

CBR EXHIBIT AT GEORGIA TECH

Atlanta, Ga. . . . Lt. Col. Oliver Hertel, Comptroller of Chemical Corps Engineering Command, demonstrating automatic field alarm to Col. William E. R. Sullivan, Deputy Chief Chemical Officer; Col. Leon A. Brock, Deputy for ROTC; Col. J. H. Dilley, Chief of Staff, Reserve Command; Dr. Paul Weber, acting president of Georgia Tech; Col. W. R. Robertson, Professor of Air Science; and Capt. L. R. Lampman, Professor of Naval Science, at Chemical Corps display of latest equipment for protection against Chemical, Biological, and Radiological Warfare at Georgia Tech.

—U. S. Army Photo

ATLANTA, GA. . . . The halls of the Hightower Textile Building, Georgia Institute of Technology, resounded recently to the sound of scraping feet as thousands of students from Tech and other schools in the area viewed the Corps latest equipment for protection against chemical, bilogical and radiological warfare.

The week-long exhibit kept a crew of Army narrators busy explaining the items and discussing their use.

A portion of the display which attracted much attention by the non-military spectators was the items dealing with civil defense. Such things as a civil defense protective mask, an infant protector and the fiber diffusion board held their interests.

Another feature of the show was an illustration of the action and effects of the new "G" gases. Many of the spectators initially expressed alarm when told that these gases were odorless, colorless, and difficult to be detected by the human senses. However, their fears were soon forgotten when they viewed the new automatic detection and warning alarm.

For members of the Atlanta Chapter, Armed Forces Chemical Association, the highlight of the week's activities was a dinner at the Officers Mess at Fort McPherson, near Atlanta. The principal speaker of the evening was Colonel William E. R. Sullivan, Deputy Chief, Chemical Corps.

PUBLIC SPEAKING CLASS AT A.C.C.

ARMY CHEMICAL CENTER, MD.—The Chemical Corps Materiel Command at the Army Chemical Center graduated its first public-speaking class on January 25. The on-duty classes are being conducted as a phase of the Materiel Command's personnel development program for special training in preparation for higher level executive positions in the future. This class consisted of: Captain Charles H. Tomlinson, Jr.; Captain Paul H. Koenig; Captain Walter W. Lepkowski; 2d Lieutenant David P. Mast; 2d Lieutenant Dave Johnston; Miss Olga Solovei; Mr. Samuel Steinberg, and Mr. David F. Bourque.

COL. DAVID ARMITAGE COMMENDED

—U. S. Army Photo

FORT MEADE, MD.—Colonel David Armitage (left in picture), former Second Army Chemical Officer, recently received a Second U.S. Army Certificate of Achievement, presented to him by Brigadier General Thomas N. Griffin, Second U.S. Army Chief of Staff (right in picture). Col. Armitage was cited for having ". . . rendered outstanding service in a position of great responsibility . . . contributed directly to the successful accomplishment of the Second U.S. Army's assigned misisons."

Colonel Armitage has a new assignment as Commanding Officer of the Dugway Proving Grounds, Dugway, Utah.

$300 AWARD TO MR. OUELLETTE

A $300 award for sustained superior performance was presented to Mr. Edward J. Ouellette of the Career Plans and Policy Branch, Career Management Division, on 1 March 1957 by the Chief Chemical Officer, in recognition of his work as Education Officer in the Research and Analysis Division of the CmlC School, Fort McClellan, Alabama.

MAJOR HOLZWORTH RETIRED

Major Elmer J. Holzworth, Executive Officer, Troop Command, Army Chemical Center, Md., who served as Adjutant and also as Company Commander of the 2nd Chemical Mortar Battalion in World War II, retired 31 January 1957, after more than 26 years service.

Major Holzworth enlisted in the Regular Army on 9 October 1930, and was commissioned as First Lieutenant, Army of the United States, in 1943. During World War II, he participated in the Naples-Foggia, Rome-Arno, Sicily, Tunisia, Rhineland, Central Europe and Southern France Campaigns. He served in Korea from 26 May 1954 until 17 October 1955 with the 4th Chemical Smoke Generator Battalion and the Chemical Depot.

SIXTH ARMY CML SECTION CHIEF CLERK WINS AWARD

An "Outstanding Performance Award" including Department of the Army Certificate for sustained superior performance of duty, Letter of Commendation and check for $100 recently was presented to Mrs. Edward (Yuen Sin L.) Lau, 1455 Leavenworth St., San Francisco, Calif., by Colonel Fred W. Ludecke, Sixth Army Chemical chief, at an informal ceremony at the Presidio of San Francisco.

Mrs. Lau was commended for amount of work accomplished and for outstanding qualities of service and loyalty to the Chemical Section of which she is now the chief clerk. Her parents, Mr. and Mrs. K. F. Lung, reside in Honolulu, T. H.

NEW YORK CHEMICAL PROCUREMENT DISTRICT MOVES TO NEW QUARTERS

Just after the New Year, the New York Procurement District, commanded by Col. Harold Walmsley, changed its address from Varick Street to 290 Broadway, New York 7, N. Y. The telephone number is Barclay 7-0800. This is the third move since World War II. The present quarters are considered the most satisfactory to date.

MRS. GARVEY GIVEN CERTIFICATE

Mrs. Vesta B. Garvey received the Chemical Corps Retirement Certificate on her retirement after 28 years as a Civil Service employee. The presentation was made on January 31, 1957 by Major General William M. Creasy, Chief Chemical Officer. Mrs. Garvey transferred to the Chemical Corps from the Corps of Engineers in 1951. Her last position was as Supply Requirements Officer, Logistics Planning Division, Office of the Chief Chemical Officer, Washington, D.C.

PINE BLUFF AWARDS

Cash awards for outstanding services recently were presented to two men and two women employees of the Chemical Corps at Pine Bluff, Arkansas, in ceremonies conducted by Lt. Colonel Frederick J. Hurley, Deputy Commander. These awards were as follows:

To Mr. Raymond Ross, Processing Inspector Foreman of Industrial Property Branch; for Sustained Superior Performance in regard to rewarehousing procedures — Certificate and $200.

To Mrs. Maxine H. Randolph, now in Civilian Personnel, formerly Property and Supply Supervisor in Industrial Property Branch; for Sustained Superior Performance in planning and operating an Excess Property Record filing system—Certificate and $200.

To Miss Vera Hawkins, of the Transportation Office; for Sustained Superior Performance as Traffic Manager—Certificate and $200.

To Mr. Robert B. Mann, Warehouseman Foreman General of Industrial Property Branch; for Sustained Superior Performance in conducting an excellent Safety Program including initiation of using an Accident Investigation Committee, a procedure now adopted for the entire arsenal—Certificate and $200. In addition, Mr. Mann received a $100 cash award for suggesting an improvement in Equipment.

SETS ENLISTED CLASS RECORD

FORT McCLELLAN, ALA.—With a score of 99.26 percent, Pvt. Grant E. Marsh of Salt Lake City, Utah, was graduated January 18, from the Chemical Corps School here with the highest scholastic average ever attained by a member of an Enlisted Entry Course. The second highest average, 99.18, went to Pvt. Norman Ware of Montgomery, Ala. The class average of 89.23 percent was the highest ever for this type of course. The 9-weeks course numbered 54 students. The subjects were chemical decontamination, smoke generation and equipment repair.

INCENTIVE AWARDS IN CHIEF'S OFFICE

Seven civilian Army Chemical Corps employees in his office were recently presented awards by Major General William M. Creasy, Chief Chemical Officer. They are, from left to right, in the picture above: Mrs. Iris L. Tilley, Executive Office, $200 for sustained superior performance which contributed to the efficiency of the Executive Office; Mrs. Nellie Briel, Administration Division, Certificate of Achievement, Honorary Award; Miss Helen L. Gravenkamp, Career Management Division, Suggestion Award of $50; Mr. Delbert H. Flint, Career Management Division, Sustained Superior Performance Award of $300; Mrs. John Morse, Career Management Division,

Sustained Superior Performance Award and check for $200; Mrs. Frances L. O'Donnell, Legal Office, Suggestion Award Certificate and check for $60. Not shown in this photo is Mr. Theodore Delavigne, Administration Division, who received the Sustained Superior Performance Award and check for $200.

LT. BUSH DECORATED

—U. S. Army Photo

Army First Lieutenant John B. Bush, Jr., son of Mr. and Mrs. John B. Bush, Sr., 407 S. Oak, Pasadena, California, was awarded the Commendation Ribbon with Metal Pendant at a review and decoration ceremony Friday, held at the Presidio of San Francisco.

Brigadier General Legare K. Tarrant, Commanding General of the Sixth Antiaircraft Regional Command, presented the award.

Lt. Bush earned his award for meritorious service during the period June 1, 1955 to December 7, 1956 while serving as technical advisor on matters pertaining to radiological defense in the Plans Organization and Training Division of the Chemical Section, Headquarters Sixth United States Army.

DR. FROLICH SPEAKS AT DETRICK

Dr. Per K. Frolich, Deputy Chief Chemical Officer for Scientific Activities, was guest speaker at the meeting of the Potomac Division of the American Phytopathological Society, March 1, at Fort Detrick, Frederick, Md. He spoke to a group at a luncheon, on the general topic of the Chemical Corps' interest in the Research and Development field.

On March 18, 1957, Dr. Frolich addressed the Washington Society of Chemical Engineers, discussing some of the problems in Technical Administration.

THE HISTORICAL CORNER

By Brooks E. Kleber *
Historical Office, Chemical Corps

MAJ. GEN. WALTER CAMPBELL BAKER

Fifth Chief of the Chemical Warfare Service

The last issue of the Journal told the sad news of the death of Maj. Gen. Walter C. Baker ,who served as the fifth Chief of the Chemical Warfare Service. This information was received too late for the inclusion of more than a brief notice. It was felt that an amplification of the details of General Baker's long career was warranted.

General Baker was born in Chester, Pennsylvania, on 22 September 1877. He joined the National Guard in 1896 and served on active duty with the 6th Pennsylvania Volunteer Infantry from May to October 1898, mustering out of the service as a sergeant. He received a Regular Army commission as a second lieutenant of Artillery in September 1901. During World War I Baker attained the rank of colonel (temporary) and was awarded the Distinguished Service Medal for his work with the Transportation Service, World War I's version of today's Transportation Corps.

In 1920 General Baker transferred to the Chemical Warfare Service. His CWS assignments included tours as Commanding Officer of Edgewood Arsenal and Commandant of the Chemical Warfare School (the jobs were coupled in the early days), Chief of the Procurement Planning Division, OC CWS, and First Corps Area Chemical Officer. While serving in the latter capacity he was chosen as Chief of the Chemical Warfare Service on 24 May 1937. After completing four years as Chief, General Baker retired at his own request in June 1941. Recalled to active duty during World War II, he was appointed liaison officer between the War Department and the War Production Board.

During his long career General Baker attended the Coast Artillery School, the Chemical Warfare School, Command & General Staff School, the Army Industrial College, and the Army War College.

General Baker served as Chief of the Chemical Warfare Service at a very difficult time—the period between the two World Wars. The CWS did well to keep its head above water during a time when the Military Establishment as a whole, and especially the CWS, was feeling the pinchings of restricted budgets. Serving as Chief when he did, General Baker was forced to reconcile meager funds for chemical warfare with the ominous shadows of another World War, shadows which finally took terrible shape in September 1939. His leadership and strength of character helped the CWS to survive and prepared the way for its important contributions in World War II.

*Member of the Staff, Historical Office, Office of the Chief Chemical Officer.

MORE AIR POWER *(Continued from page 37)*

contributing to the development of better fuels and lubricants. Chemistry is also aiding in the study of combustion processes and rocket propellants. Synthetic textiles and plastics have been developed to meet present operational requirements. Adhesives have replaced rivets in certain instances and elastomers have provided better seals, coatings and hoses. Metallurgical science is making such metals as titanium more available at less cost. Transistor developments and printed circuitry will materially reduce space and weight requirements. Photographic processes are constantly being improved and study of the upper atmosphere is increasing our knowledge of its composition and suitability for space travel. It is readily apparent that we are obtaining "More Air Power For Survival—Through Chemistry."

MOLDED DRUMS *(Continued from page 38)*

of the plastic drum following drop testing. In every case the leaks were stopped by tightening the closure. Failure of the polyethylene drum in all but one case was attributed to puncture from metal staples and/or protruding nails. The one exception was an apparently clean break about 6 in. long (fig. 3) observed at the junction of the sidewall and head sheet section of a 30-gallon drum with an open-flange plywood drum over-pack.

Figures 4 to 7 show effects of the rough-handling tests on over-pack units.

There appeared to be no doubt that the polyethylene containers, per se, were entirely adequate to withstand great abuse and would be more than satisfactory replacements for glass carboys in this respect. The major decision to be made on the basis of our test results was then which over-packs were most suitable for the drums. All factors such as damage to the over-pack, damage to the polyethylene drum size of container, abrasion, leaking, and the like were considered, and final conclusions were that:

1. The standard steel drums are the most suitable over-packs of the three types tested for use with the polyethylene drums.
2. Plywood drums and wirebound crate over-packs of the types tested appear unsuitable for use with the plastic drums, but should be further developed by industry to overcome their defects as they can probably offer significant economic advantages.

It was recommended that molded polyethylene drums, in steel drum over-packs for the present, be considered to replace glass or ceramic liners in rigid shipping containers for corrosive and sensitive materials which are compatible with polyethylene.

Final coordinations are being effected with other government agencies and interested industrial firms and the Chemical Corps expects in the near future to adopt these polyethylene carboys as one more in the growing list of packaging advances by industry which enable better protection of material and greater efficiency in the supply and logistics program of the Armed Forces.